VOLUME 58 [W. B. No. 1021] NUMBER 7

MONTHLY WEATHER REVIEW

JULY, 1930

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UNITED STATES DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
WASHINGTON, D.C.

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CORRECTIONS

Monthly Weather Review:

Index for 1925: Page vi, under entry "Day, P. C. The drought of 1925," pp. "310-311" should be "410-411." Likewise, under entry "Droughts" (same page), change the page numbers from "310-311" to "410-411."

April, 1926: Vol. 54, p. 144, in Table 18, bottom of third column, "38.50" should be "28.50."

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

VOL. 58, No. 7
W. B. No. 1021

JULY, 1930

CLOSED SEPTEMBER 3, 1930
ISSUED OCTOBER 2, 1930

WEEKLY SUCCESSION OF GULF STREAM TEMPERATURES IN THE STRAITS OF FLORIDA

By CHARLES F. BROOKS and EDITH M. FITTON

[Clark University, Worcester, Mass., April 30, 1930

Sea water thermograms of twice daily crossings of the Straits of Florida were presented in the previous paper. (1). This discussion deals with the data tabulated from these thermograms and reduced to weekly means.

REDUCTION TO TABULAR FORM

A detailed study of the temperatures recorded by the thermograph requires the tabulation of the thermograms. Each trip of the ship provides a profile from which any number of temperatures may be read. The sharp contrasts in temperature that occasionally develop within short distances leads the investigator to read the thermograms for as small time intervals as practicable. The limits of detailed study would seem to be reached by mean and extreme values for each twelfth of the width of the Straits, and for the passage of the ship through the shallow waters at each end of the trip. Furthermore, the mean sea temperatures recorded at Key West or Habana provide a rough indication of the level to which the weather then prevailing was tending to raise or lower the Gulf Stream temperatures. Thus, if the shallow harbor water were much warmer than the Gulf Stream, we conclude that local weather was having a decided warming effect on the surface of the Gulf Stream.

Method of tabulation.—The tabulation of these values has been beset with many difficulties. For reading without the aid of a special time scale, a trip across the Straits is divided into twelfths, by taking the time from sea buoy to sea buoy, or from sea buoy to hauled log [1] plus 5 or 10 minutes, and dividing by 12. The number of minutes found in each twelfth is usually from 35 to 40 for the southbound trip and 30 to 33 for the northbound. The proper number of minutes is added to the outgoing sea-buoy time, giving the clock time during which the first twelfth was traversed. The number added again shows the limits of the second twelfth, etc. The thermogram must be examined with care to note whether the clock error for the trip exceeded a negligible 5 or 10 minutes. In spite of the engineer's careful attention, the smallness of the time scale, about 0.1 inch per hour, makes an error of less than 20 minutes difficult to avoid. The characteristic features of temperature change at the beginning and end of each trip make it readily possible, however, to gauge the amount of clock error. Once found, the times for each twelfth are corrected to the apparent time on the thermogram. Then the temperatures can be integrated for each twelfth to the nearest tenth or two-tenths of a degree Fahrenheit and recorded on a convenient form.

Much labor may be saved by ruling a thin sheet of celluloid with 12 equally spaced diverging curved lines crossed nearly perpendicularly by a number of equally spaced straight lines. The curved lines are drawn so that near one end of the scale the space between the two outermost lines is equal to the thermogram time-scale value for the shortest trip, while near the other end of the scale, the diverging lines are so adjusted that the total width between the outermost lines equals the longest time required to cross. The cross lines are marked numerically to indicate how long a trip each one represents. The cross line appropriate to the duration of the trip to be tabulated is placed over the record for the first twelfth in a position parallel to the horizontal temperature-scale lines on the thermogram. By slight shifting up or down this cross line can be made to strike an average for each twelfth in succession, by laying it so that the area outlined by the trace is as much above as below the line. But it is usually easier to hold the scale stationary and to estimate the means for each twelfth. The highest and lowest temperatures of each twelfth, or of each quarter with the hour and minute each occurs, and also the temperatures from sea buoys to harbors complete the tabulation. The tabulation is checked by another person by a second reading.

The primary tabulation is summarized onto another sheet, from which times are omitted, and here the twelfths are averaged by quarters and by halves from which the end twelfths have been omitted. The daily values are averaged into weekly. The *Henry M. Flagler* thermograms from July, 1928, to May, 1929, were tabulated by Hazel V. Miller, mostly at the Washington office, United States Weather Bureau, on grants from the American Meteorological Society and Clark University. Those from May, 1929, to June, 1930, were tabulated at Clark University, by Edwin N. Johnson and Frances Richey. All the tabulations were checked by C. F. Brooks and Edith M. Fitton. The receipt of sea-buoy and hauled log times in October, 1929, from Capt. W. I. Jackson and Chief Engineer C. H. Stanton, S. S. *Henry M. Flagler*, which before December, 1928, and May, 1929, respectively, were not entered on the thermograms, made a more exact tabulation of parts of the first few months of record possible. So those strips for which the exact times showed more than 5 or 10 minutes' departure from the original readings were tabulated a second time, mostly

[1] The time when the patent log is hauled in at the end of a trip, usually a mile or two (5 or 10 minutes) off the harbor entrance. Sometimes the ship waits outside for its sister ship to come out of the single berth. Thus, the hauled log time may be half an hour to an hour or more before the ship passes the sea buoy to enter the harbor.

by C. F. Brooks, the first tabulations being used as a partial check on the new. Where the hauled log times were no more than 10 minutes prior to the Habana sea-buoy times, the hours and minutes from sea buoy to sea buoy were used as the whole crossing, and divided into twelfths.

Owing to the sharp changes in temperature found on some of the thermograms, particular care had to be exercised to read the time to within 10 minutes and to strive for 5. An error of 10 minutes might make a difference of 1° in the mean for one twelfth.

The tabulations by days are not presented in this study for the reason that they would serve only for a detailed investigation of temperature changes from day to day and diurnal ranges and their relation to the weather at the time and the immediate past.[2] Here are offered in Table 1, the weekly values, tabulated, reduced, and checked, by C. F. Brooks, and Edith M. Fitton and in part by Hazel V. Miller, by which, in spite of the gaps, a fair idea of the annual course in temperature may be obtained. In Table 2 the weekly means of the daily temperatures by quarters and weekly means by halves

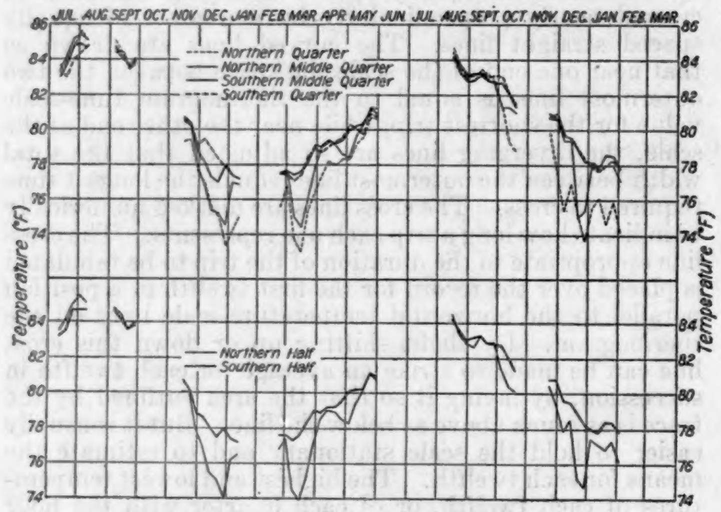

FIGURE 1.—Gulf Stream temperatures (south bound) by quarters and halves

of the Straits are presented. The values for the north and south halves in this table were computed from the weekly means inner ten twelfths of the Straits proper, omitting the marginal twelfths on either side, since these sections of the Straits, being shallower water and out of the main current, are more subjected to local temperatures and shallow water upwelling from wind action.

GRAPHIC REPRESENTATIONS OF TABULATIONS

These tables are presented here to provide investigators with accurate Gulf Stream data in small enough time and space units for any combinations they may desire. The graphic representations of the tabulations which are presented in Figures 1 to 3 may serve to make more prominent the outstanding features of the weekly course of temperature for the different divisions of the Gulf Stream in the Straits.

Figure 1 illustrates the weekly succession of temperatures for each of the four quarters of the Gulf Stream in the open Straits from the Key West sea buoy to the Habana sea buoy from July, 1928, to February, 1930. The southbound (nighttime) trips were chosen because the nighttime temperatures represent those of a convectionally mixed thicker layer of water than the top, heated, daytime layer. Nevertheless, there is naturally a very close parallelism between the temperatures of the southbound and northbound trips since the car ferry stays in Habana Harbor only about two hours before returning, and not much change in sea water temperature could generally be effected in that length of time. Moreover, the graphs show weekly averages, so any irregular variations that might occur between the two trips become more or less smoothed out, and only the small diurnal difference remains. In the 56 cases for which weekly averages of sea temperatures were obtained, July, 1928, to February, 1930, the nighttime temperatures average 0.31° F. below the daytime for the north half of the Straits and 0.24 °F. below for the south half. For the north half there were 42 cases of lower nighttime temperature (av. $-0.45°$ F.), 8 cases of higher nighttime temperature (av. $+0.22°$ F.), and 6 cases of the same temperature. For the south half there were 44 cases of lower temperature (av. $-0.32°$ F.), 4 cases of higher temperature (av. $+0.12°$ F), and 8 cases of the same temperature.

The contrast between the north and south portions of the Straits is plainly shown in this graph. While for the width of the Straits as a whole, the annual range of sea surface temperature is 9° F., from 76° to 85°, the north quarter has a greater range than the south, being 2° or 3° colder in winter and 1° or less warmer in summer, a range of 11.7°, from 73.4° to 85.1°, compared with 7°, from 77.5° to 84.5°, in the south. During August and September, all four quarters are nearly alike in temperature, as is shown by the close crowding of the lines in the graph in these months, the temperatures for all the quarters occurring within the limits of less than one degree then, while during the winter months the limits are generally 4 or 5 degrees apart. The weekly course of temperature by halves, bottom of Fig. 1, summarizes this contrast between north and south. The north half ranges 10.7°, from 74.3° to 85.0°, and the south half 7°, from 77.5° to 84.5°.

The chief reason for the greater temperature range in the north portion of the Straits probably lies in the fact that the water comes mainly from the Gulf of Mexico, while the Caribbean supplies the south portion. The north portion thus receives a water supply from a source which (*a*) is more subject to continental temperature changes, (*b*) comes from a higher latitude, (*c*) is shallower in part, and (*d*) provides a current generally less strong, than in the south portion.

The lowest temperatures are reached in the northernmost quarter; the major minimum comes in March, with a secondary (cool wave) minimum in December. The northernmost quarter also reaches the highest temperature, its maximum coming in late July or early August. Because the record is broken in these two months in both years, it is difficult to state an exact maximum, as it might have been reached during the time when the car ferry was making no trips.

Figure 2 permits comparison of the Gulf Stream temperatures at the same dates in the two successive years. The graph runs from July to June, and, so far, is double only from July to April. As more thermograms are received year after year, the graph can be added to and will then show more clearly whether there is parallelism or not from year to year. The figures from which the graph was made (see table 2) are for the north and south halves of each trip, from which the more locally influenced marginal twelfths have been omitted. It seems fairly

[2] The daily values are being filed, however, in the Library, and the original records with the Marine Division, of the United States Weather Bureau, Washington.

certain that marked parallelism from year to year will continue to be found, since those portions of the graph which are now double show a very close parallelsim between 1928–29 and 1929–30 for both north and south halves of the stream. Even the exceptional early winter drop in temperature in the north half occurs at the same time in both of the years of record—the end of December—perhaps only by coincidence, however.

The relation of local air temperatures to the Gulf Stream temperatures was studied by means of diagrams. Averages of Key Wext maximum, minimum, and mean air temperatures were calculated for the same weeks for which sea water temperatures were obtained and were plotted on graphs together with the following sea tempera-

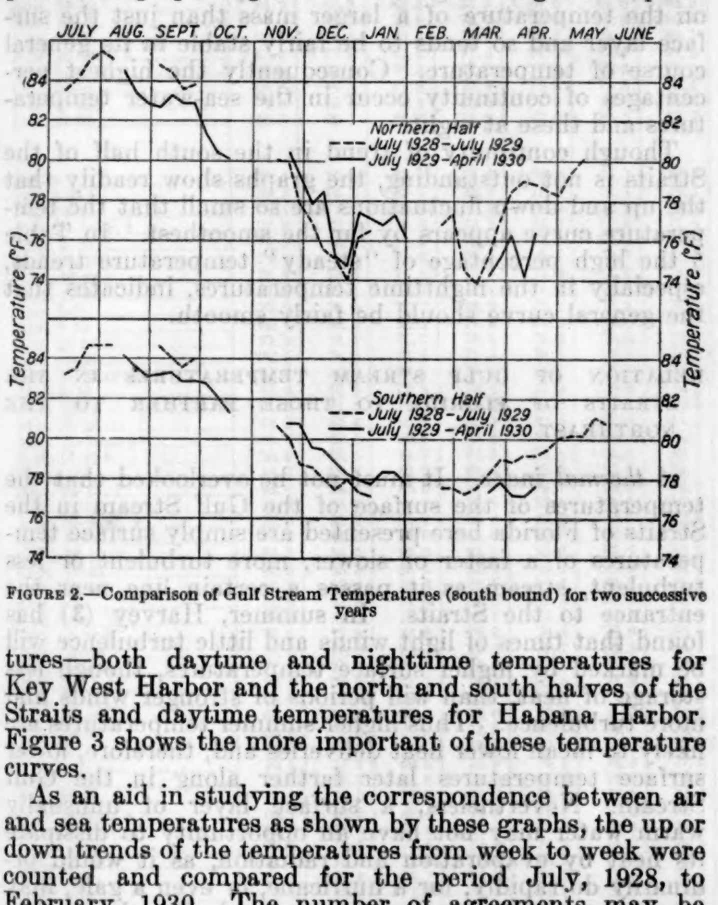

FIGURE 2.—Comparison of Gulf Stream Temperatures (south bound) for two successive years

tures—both daytime and nighttime temperatures for Key West Harbor and the north and south halves of the Straits and daytime temperatures for Habana Harbor. Figure 3 shows the more important of these temperature curves.

As an aid in studying the correspondence between air and sea temperatures as shown by these graphs, the up or down trends of the temperatures from week to week were counted and compared for the period July, 1928, to February, 1930. The number of agreements may be designated by the letter (A). Using the air temperature as a base in each case the number of times that the up or down trends of the sea temperatures agreed with the air temperatures was ascertained; the same was done for different combinations of the sea temperatures. When completed, the following comparisons had been secured.

Maximum air temperatures with daytime temperatures of Key West Harbor, and the north and south halves of the Straits.

Minimum air temperatures with nighttime temperatures of Key West Harbor, and the north and south halves of the Straits.

Mean air temperatures with both day and nighttime temperatures of Key West Harbor and the north and south halves of the Straits.

Both day and nighttime Key West Harbor temperatures with the north and south halves of the Straits.

Both day and nighttime temperatures of the north half with those of the south half of the Straits.

Mean Habana Harbor temperatures (daytime) with maximum air temperatures of the south half of the Straits.

Maximum air temperatures with nighttime temperatures of Key West Harbor and the north and south halves of the Straits.

Table 3 shows the per cent the agreements of the up and down trends actually found, are of the maximum possible number of agreements.[3] The agreements are always well over 50 per cent of the possible and generally over 75 per cent. A study of the table reveals the following general facts: (*a*) the daytime trends generally agree more frequently than the nighttime trends; (*b*) the down trends generally agree more frequently than the up trends; and (*c*) the maximum air temperature agrees more frequently with the daytime sea temperature than the minimum air temperature does with the nighttime sea temperature. An explanation for points (*a*) and (*c*) will be brought out in the discussion of Table 4. The truth of point (*b*) depends upon the fact that the winds causing a falling air temperature would have more effect on sea surface temperatures because of convection, than would winds causing a rising air temperature.

In order that the relation between the air and sea temperatures might be expressed conveniently, a percentage relation was obtained and is presented in Table 4. The number of agreements between the up or down trends of each two curves that would occur merely by chance (C) was calculated[4] and the difference between this figure and the actual number of agreements noted was found (A–C). The maximum possible number of agreements

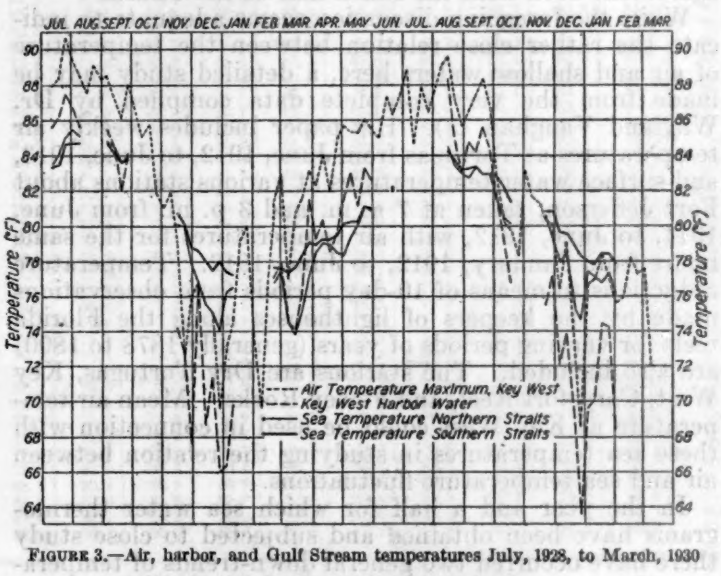

FIGURE 3.—Air, harbor, and Gulf Stream temperatures July, 1928, to March, 1930

was ascertained[3] (M) and the difference between this figure and the chance agreements (M–C) was taken as the hundred per cent which would represent the amount over and above a chance agreement the actual agreements (A) might reach. The ratio between the first difference (A–C) and this figure (M–C), may be taken as a percentage measure of relationship.

The same facts are brought out in this table as in Table 3: (*a*) the agreement between the up or down

[3] The maximum number of agreements possible would be the lesser total of the ups or downs of the two curves.

[4] The number of ups or downs in one curve times the corresponding number in the other curve, divided by the total number of interweekly trends (the number of weeks minus one, plus the number of breaks).

temperature trends for either air and water temperatures or different water temperatures is always above what would be expected merely by chance; (*b*) the nighttime temperatures never have as high an agreement as the daytime temperatures when the comparison is between air and water temperature; (*c*) the maximum air temperature has a percentage of agreement with the daytime sea temperatures more than twice as high as that of the minimum air temperature with the nighttime sea temperatures.

Since the maximum air temperature has the largest percentages of agreement with the ocean temperature it is evident that daytime air temperatures at Key West are a better index to the whole effect of local influences on the temperature of the water than are nighttime Key West temperatures. This is probably because the air minima are less representative of the general air temperature than are the maxima, owing to the less convection at night. Furthermore, the convection set up in the water by the cooling of the surface layer at night would tend to stir the water considerably, thereby operating to prevent its temperature agreement with the air at that time. An explanation for points (*b*) and (*c*) listed in the preceding paragraph and for the similar points (*a* and *c*) in the discussion of Table 3, may be based on this conclusion.

The highest percentage of agreements in excess of what would be expected by chance occurs between the air temperatures and the Key West Harbor temperatures, as would be expected. The air temperature has a high agreement also with the north half of the Straits, though much less than with Key West Harbor, and a fairly high agreement even with the south half of the Straits.

While the foregoing discussion seems adequate to indicate the rather close relation between the temperature of air and shallow waters here, a detailed study may be made from the very complete data compiled by Dr. Wayland Vaughan (*2*). His paper includes weekly air temperatures at Tortugas from June, 1912, to June, 1913, and surface water temperatures at various stations about Fort Jefferson, taken at 7 a. m. and 3 p. m. from June, 1911, to June, 1912, with air temperatures for the same hours from January, 1912, to June, 1912. Temperature reductions to means of 10-day periods from observations made by the keepers of lighthouses along the Florida reefs for varying periods of years (generally 1878 to 1890) are also included. The stations are Dry Tortugas, Key West, Carysfort Reef, and Fowey Rocks. Mean air temperature at Key West could be used in connection with these sea temperatures in studying the relation between air and sea temperature fluctuations.

In the year and a half for which sea water thermograms have been obtained and subjected to close study there have occurred two general down-trends of temperature (September, 1928, to March, 1929, and August, 1929, to February, 1930) and only one up-trend (March to August, 1929, and a very short upward record in July and August, 1928). A smooth curve then would be represented by twice as many downs as ups and, except at the three turning points, each down trend should be followed by a down trend and each up trend by another up trend. Table 5 shows what was actually found to be the case.

The Key West and Habana Harbors show the lowest per cent of continuity of temperature trend, even lower than the air temperatures. Though this may appear to be an anomaly, it might well be expected in this case inasmuch as the harbor temperatures were reported at different hours in different weeks, and particularly, were more subject to irregular extremes resulting from mixing of outtake waters with the intake around the docks, and from winds blowing the warm surface waters on-shore or off-shore.

The nighttime Gulf Stream temperatures show the greatest continuity of trend, the nighttime air temperatures the least. The nighttime air temperatures are minimum air temperatures, which, being under considerable local control in quiet weather, tend to follow a very zigzag course from week to week. At nighttime, the water, however, being more stirred by convection, takes on the temperature of a larger mass than just the surface layer and so tends to be fairly stable in its general course of temperature. Consequently the highest percentages of continuity occur in the sea-water temperatures and these at night.

Though continuity of trend in the south half of the Straits is not outstanding, the graphs show readily that the up and down fluctuations are so small that the temperature curve appears by far the smoothest. In Table 5 the high percentage of "steady" temperature trends, especially in the nighttime temperatures, indicates that the general curve should be fairly smooth.

RELATION OF GULF STREAM TEMPERATURES IN THE STRAITS OF FLORIDA TO THOSE FARTHER TO THE NORTHEAST

A thermal index.—It must not be overlooked that the temperatures of the surface of the Gulf Stream in the Straits of Florida here presented are simply surface temperatures of a faster or slower, more turbulent or less turbulent, stream as it passes a certain line near the entrance to the Straits. In summer, Harvey (**3**) has found that times of light winds and little turbulence will be marked by higher surface temperatures, though less storage of heat, than will periods of stronger winds and more turbulence. Thus higher summer temperatures are likely to mean lower heat deliveries and, therefore, lower surface temperatures later farther along in the Gulf Stream. Nevertheless, a surface layer of unusually warm water may not have an opportunity to dissipate its heat by evaporation and radiation, as it would ordinarily do rapidly, for a hurricane, or even a gale, may stir it into a deep body of water, reducing the surface temperature so that the heat will be conserved till farther than usual along the course of the stream. British investigators might, in consequence, expect higher temperatures in the eastern North Atlantic some months after a period of numerous West Indian hurricanes. If the hurricanes occurred mostly east of Key West the variations of Gulf Stream temperatures near Key West might have no apparent relation to those of the same water later observed two or three thousand miles along its course. Herein lies the importance of recording the temperatures, as it is now being done (**4**), across the Stream on several lines after the Gulf Stream leaves the Straits. Therefore, these tables are presented simply for what they are. It is hoped, through the navigational record of the car ferries, to get some knowledge of the current each day, and thus, with the temperatures, to provide some index to the thermal cargo carried.

TABLE 1.—*Average weekly temperature values for Key West and Habana Harbors, extremes from the harbors to the sea buoys, and means by twelfths across the Straits of Florida, July 1928 to February 1930*

	Key West Harbor	Key West—Sea buoy: Maximum	Key West—Sea buoy: Minimum	1	2	3	4	5	6	7	8	9	10	11	12	Sea buoy—Habana: Minimum	Sea buoy—Habana: Maximum	Habana Harbor
1928																		
July 9-14	85.6	85.7	84.3	83.8	83.6	83.5	83.5	83.5	83.3	83.1	83.0	83.2	83.4	83.4	83.2	82.4	86.6	83.7
July 15-21	86.2	86.1	83.7	83.6	83.9	84.1	84.2	84.1	84.2	83.9	83.7	83.5	83.2	83.1	82.5	82.1	85.0	83.5
July 22-28	87.5	88.0	85.2	85.0	84.8	84.8	85.2	85.2	85.2	85.0	84.8	84.6	84.5	84.2	83.1	82.7	85.3	84.1
July 29-Aug. 4	86.7	88.9	85.6	85.5	85.6	85.6	85.5	85.4	85.3	85.2	84.9	84.6	84.4	84.4	84.2	83.3	86.6	84.6
Aug. 5-11 [1]	85.6	85.7	85.0	85.1	85.1	85.0	85.1	85.0	85.0	84.8	84.7	84.5	84.8	84.9	84.6	83.9	86.9	85.0
Sept. 3-9	85.5	85.9	84.8	85.1	85.1	85.0	84.7	84.5	84.5	84.7	84.7	84.8	84.7	84.5	83.9	83.1	86.1	84.1
Sept. 10-16	84.5	84.7	84.1	84.4	84.4	84.5	84.5	84.4	84.2	84.2	84.1	84.1	84.1	84.1	84.0	83.8	85.9	84.6
Sept. 17-23	82.0	82.4	81.6	83.2	83.6	83.6	83.6	83.6	83.4	83.4	83.7	83.7	83.6	83.6	83.6	83.3	84.7	84.2
Sept. 24-30 [2]	84.2	84.3	83.5	83.9	84.0	84.0	83.9	83.7	83.6	83.7	83.9	84.1	84.1	84.0	83.7	83.4	85.8	84.4
Nov. 12-18	74.2	78.3	73.8	78.9	79.3	79.8	80.4	80.5	80.6	80.7	80.7	80.7	80.7	80.8	80.3	78.4	80.0	79.8
Nov. 19-25	72.8	76.5	70.0	78.8	79.5	79.8	80.1	80.3	80.3	80.4	80.2	80.0	80.0	80.0	79.8	77.5	80.1	78.1
Nov. 26-Dec. 2	67.6	77.0	67.3	77.4	77.6	77.9	77.8	77.8	78.3	78.3	78.7	78.9	79.1	79.2	79.0	74.1	78.8	74.8
Dec. 3-9	76.9	77.4	76.4	77.0	77.1	77.0	76.6	76.6	77.2	77.9	77.9	78.4	79.5	79.6	79.5	77.2	78.4	77.5
Dec. 10-16	68.6	74.3	67.8	75.4	75.8	75.5	75.4	75.3	75.6	76.6	77.2	78.3	78.9	79.0	78.8	74.8	78.4	75.4
Dec. 17-23	71.5	75.0	71.3	75.3	74.9	74.8	74.8	74.8	76.0	76.6	76.8	77.7	78.3	78.3	78.2	75.5	76.9	76.8
Dec. 24-31	66.0	72.7	66.5	73.2	73.4	73.5	73.7	73.2	76.5	77.7	78.1	78.2	77.9	77.9	77.8	73.2	77.4	74.4
1929																		
Jan. 1-7	66.4	72.6	65.1	73.0	74.0	75.7	76.8	77.1	77.2	77.4	77.4	77.5	77.4	77.4	77.3	74.7	77.2	74.8
Jan. 8-14 [3]	69.8	73.3	68.5	73.6	75.3	76.4	76.7	77.0	77.1	77.2	77.3	77.2	77.2	77.2	77.3	75.2	77.0	76.0
Feb. 19-25	77.1	77.1	74.6	75.2	75.4	76.2	77.4	77.4	77.5	77.5	77.6	77.5	77.6	77.6	77.4	77.1	79.0	78.2
Feb. 26-Mar. 3	77.9	77.8	75.5	76.2	76.9	77.4	77.6	77.6	77.5	77.6	77.6	77.6	77.6	77.5	77.4	77.4	78.9	77.7
Mar. 4-10	74.5	75.6	72.5	73.5	73.9	73.9	73.8	76.4	76.4	77.3	77.4	77.4	77.2	77.1	77.0	76.7	78.0	77.3
Mar. 11-17	74.1	73.9	72.9	73.2	73.1	72.7	73.0	73.9	76.2	77.4	77.6	77.7	77.6	77.5	77.1	76.4	77.2	77.2
Mar. 18-24	76.3	76.6	75.5	75.8	75.2	75.0	74.6	74.9	76.2	78.0	78.3	78.4	78.5	78.6	78.4	78.1	79.6	79.0
Mar. 25-31	81.6	81.4	77.7	77.1	76.4	75.8	76.2	78.3	79.1	79.2	79.2	79.0	78.9	78.8	79.0	78.8	80.9	79.8
Apr. 1-7	79.2	79.5	77.7	76.9	77.2	78.1	78.9	79.2	79.1	79.1	79.0	78.9	78.8	78.8	78.7	78.4	80.4	79.9
Apr. 8-14	80.4	80.2	78.2	77.9	78.0	78.6	79.4	79.5	79.4	79.4	79.3	79.2	79.2	79.0	78.9	78.8	80.6	79.6
Apr. 15-21	77.5	78.1	75.7	76.9	78.2	78.8	79.0	79.1	79.2	79.2	79.2	79.2	79.2	79.2	79.3	79.3	80.7	80.3
Apr. 22-28	79.6	79.5	77.2	78.2	78.6	78.2	78.3	78.6	78.8	79.2	79.5	79.6	79.6	79.5	79.5	79.6	81.5	80.0
Apr. 29-May 5	81.5	82.4	79.4	78.4	78.2	78.2	78.2	78.1	78.7	79.5	80.2	80.3	80.3	80.4	80.3	80.0	82.8	81.2
May 6-12	83.0	82.5	79.8	79.6	79.2	79.0	79.0	79.9	80.1	80.3	80.3	80.2	80.2	80.1	80.0	79.8	83.2	81.8
May 13-19	81.1	81.1	79.5	79.4	79.5	79.9	80.3	80.3	80.3	80.4	80.4	80.3	79.9	79.8	79.3	78.7	82.0	80.6
May 20-26	83.3	83.4	80.7	80.5	80.5	81.0	81.2	81.4	81.3	81.2	81.2	81.1	81.0	80.9	80.7	80.1	82.8	81.3
May 27-June 2 [4]	82.6	82.5	80.6	80.6	80.6	80.7	81.1	81.3	81.3	80.9	80.7	80.8	80.7	80.8	80.7	80.0	83.3	80.0
June 17-23 [5]	83.6	83.5	81.7	81.5	81.5	81.8	82.1	82.1	82.3	82.4	82.3	82.1	81.9	81.9	81.8	81.3	83.9	82.5
July 1-7 [6]	88.3	88.6	83.0	83.4	83.3	83.2	83.1	83.0	82.8	82.9	83.0	82.9	82.8	82.8	82.7	82.7	87.0	83.9
Aug. 12-18	88.4	88.5	85.0	84.9	84.7	84.5	84.4	84.5	84.3	84.2	84.2	84.2	84.2	84.2	84.2	83.5	86.7	84.6
Aug. 19-25	84.9	85.3	83.9	83.8	83.6	83.3	83.1	83.3	83.5	83.6	83.7	83.6	83.6	83.3	82.7	82.5	85.2	83.7
Aug. 26-Sept. 2	83.0	83.3	81.9	82.8	82.9	83.0	82.8	82.8	82.9	83.0	83.1	83.3	83.2	83.1	82.8	81.6	84.0	82.7
Sept. 3-9	84.8	84.6	83.0	83.0	82.8	82.6	82.6	82.6	83.0	83.2	83.1	83.2	83.2	83.2	83.2	82.3	86.2	83.8
Sept. 10-16	84.2	84.5	83.6	83.4	83.6	83.4	83.2	83.1	83.1	83.2	83.3	83.3	83.4	83.3	83.3	82.8	85.6	83.8
Sept. 17-23	85.6	85.6	83.4	83.4	83.2	83.0	82.9	82.7	82.6	82.6	82.9	83.1	83.0	83.0	83.0	82.6	85.3	83.6
Sept. 24-30	84.3	86.0	82.6	82.5	82.6	83.3	83.2	82.7	82.6	82.5	82.7	82.8	83.0	83.2	83.1	83.3	85.2	84.3
Oct. 1-7	81.8	81.8	81.0	81.3	81.5	81.4	81.6	80.6	81.8	82.5	82.7	82.9	82.8	82.9	83.1	83.5	85.4	84.8
Oct. 8-14	79.4	81.0	78.7	80.1	79.1	79.2	80.4	81.5	82.0	82.0	82.1	82.1	82.1	82.1	82.2	81.8	83.8	83.0
Oct. 15-21 [7]	76.8	77.8	76.6	78.6	78.8	78.9	80.2	81.3	81.4	81.3	81.2	81.3	81.5	81.3	81.1	91.1	83.0	82.4
Nov. 19-25	75.5	78.5	75.3	79.2	79.7	80.3	80.7	81.0	81.0	80.9	80.8	80.8	80.7	80.7	80.6	79.4	80.1	80.3
Nov. 26-Dec. 2	77.2	77.8	76.6	77.5	77.4	77.5	79.9	80.8	81.0	80.9	80.9	80.9	80.8	80.7	80.4	79.4	82.6	80.8
Dec. 3-9	72.1	74.0	71.7	75.1	75.4	75.9	78.7	79.6	79.7	79.6	79.6	79.6	79.7	79.6	79.7	78.3	80.4	79.2
Dec. 10-16	73.9	76.9	73.0	76.7	77.3	77.0	79.0	79.6	79.5	79.5	79.5	79.5	79.5	79.4	79.4	78.4	80.5	79.3
Dec. 17-23	69.5	75.2	69.3	75.0	75.8	74.9	74.2	75.2	75.6	78.5	78.9	79.2	79.0	78.9	78.7	75.5	78.6	77.2
Dec. 24-31	63.6	73.6	61.9	73.8	73.7	73.4	74.3	75.3	76.7	77.9	78.2	78.4	78.4	78.4	78.2	73.4	76.3	76.6
Jan. 1-7	69.5	74.0	67.7	74.2	75.4	77.0	78.0	78.2	78.2	78.2	78.1	78.0	78.0	77.9	77.7	74.8	77.8	75.8
Jan. 8-14	70.1	75.4	69.6	75.9	76.1	76.3	77.2	77.9	77.9	78.0	77.8	77.7	77.7	77.7	77.6	74.9	77.4	75.8
Jan. 15-21	74.4	74.3	73.6	74.0	73.9	76.2	77.8	78.0	78.3	78.7	78.7	78.4	78.2	78.2	77.6	75.6	78.2	77.6
Jan. 22-28	74.2	75.3	73.1	75.2	75.9	76.5	77.4	78.3	78.4	78.4	78.5	78.5	78.5	78.4	77.9	76.8	79.2	77.9
Jan. 29-Feb. 4 [8]	68.4	73.3	69.6	73.5	74.0	75.2	76.3	77.5	77.6	77.8	77.8	77.8	77.8	77.8	77.7	75.6	77.5	76.2
Mar. 11-17 [9]	75.6	74.5	72.4	74.3	74.4	73.3	73.4	73.0	75.4	77.3	77.7	77.9	77.6	77.6	77.7	77.0	80.0	77.7
Mar. 18-24	77.5	76.6	74.4	75.1	74.8	74.7	74.5	75.1	76.1	77.1	78.1	78.4	78.4	78.3	78.2	78.0	79.9	78.7
Mar. 25-31	74.5	75.9	72.5	73.4	73.5	73.6	74.4	75.4	77.1	77.8	78.0	78.2	78.3	78.3	78.3	78.1	79.3	78.8
Apr. 1-7	76.7	77.8	73.7	74.5	74.7	75.6	76.7	77.8	78.0	78.0	77.9	77.8	77.7	77.6	77.7	77.6	80.0	78.3
Apr. 8-14	74.1	74.6	72.7	74.5	74.1	73.6	73.9	73.8	76.3	77.7	77.8	77.8	77.8	77.7	77.7	76.9	79.0	78.4
Apr. 15-21	79.1	79.5	75.5	75.4	75.3	76.2	67.8	77.6	78.6	78.6	78.5	78.3	78.3	78.2	78.2	77.8	80.5	78.7
Apr. 22-28	78.8	79.2	77.2	77.7	77.9	78.3	78.2	78.4	78.6	79.3	79.7	79.7	79.5	79.0	78.8	78.4	81.0	79.5
Apr. 29-May 5	79.8	80.1	78.5	78.3	78.1	77.8	77.5	77.5	78.4	79.4	79.7	79.6	79.5	79.3	79.3	79.2	83.3	80.6
May 6-12	80.5	80.6	79.0	78.4	78.1	78.3	78.7	79.5	80.0	80.4	80.4	80.3	80.1	79.7	79.3	79.1	82.5	80.8
May 13-19	82.8	83.4	79.9	79.7	79.7	79.9	80.4	81.2	80.9	80.9	80.9	80.7	80.7	80.9	80.8	80.5	84.2	81.7
May 20-26	84.4	84.4	81.3	81.6	82.0	82.1	82.0	81.9	81.9	81.9	81.9	81.7	81.6	81.3	80.7	79.9	83.4	81.7
May 27-June 2	82.9	83.0	80.7	81.1	80.9	81.0	80.8	81.0	81.1	81.3	81.6	81.4	81.6	81.7	81.7	80.0	82.3	80.8
June 3-9	79.1	79.5	78.1	79.5	79.6	79.3	79.8	80.3	80.3	80.5	80.7	80.7	80.9	80.9	81.2	81.3	82.7	81.3

[1] Aug. 19 to Sept. 2, 1928. No record; ship in port.
[2] Oct. 1 to Nov. 11, 1928. No record; ship in port.
[3] Jan. 15 to Feb. 18, 1929. No record; ship in port.
[4] June 3 to June 16, 1929. No record; ship in port.
[5] June 24 to June 30, 1929. No record; ship in port.
[6] July 8 to Aug. 11, 1929. No record; ship in port.
[7] Oct. 22 to Nov. 18, 1929. No record; ship in port.
[8] Feb. 5 to Mar. 10, 1930. No record; ship in port.
[9] Record for 1 day only in this week.

TABLE 1.—*Average weekly temperature values for Key West and Habana Harbors, extremes from the harbors to the sea buoys, and means by twelfths across the Straits of Florida, July 1928 to February 1930*—Continued

1928	Habana harbor	Habana to Sea buoy		12	11	10	9	8	7	6	5	4	3	2	1	Sea buoy to Key West		Key West harbor
		Maximum	Minimum													Minimum	Maximum	
July 9-14	83.6	85.8	83.2	83.4	83.6	83.5	83.4	83.2	83.3	83.7	83.9	84.1	84.1	84.1	84.2	84.0	86.3	85.8
July 15-21	83.5	85.1	82.5	82.5	82.9	83.4	83.6	83.9	84.2	84.4	84.4	84.5	84.3	84.3	84.1	83.8	86.5	86.2
July 22-28	84.5	85.0	82.0	83.5	84.9	84.9	84.8	85.4	85.7	86.0	86.2	86.5	86.6	85.9	85.7	87.0	88.5	88.3
July 29-Aug. 4	84.9	86.3	83.6	84.2	84.5	84.7	84.8	85.1	85.5	85.7	85.9	85.9	85.9	86.0	86.0	85.8	87.7	87.0
Aug. 5-11 [10]	85.0	87.1	84.4	85.1	85.2	84.8	84.9	85.3	85.3	85.4	85.5	85.4	85.3	85.3	85.3	85.3	86.2	85.2
Sept. 3-9	84.0	85.8	83.2	84.1	84.6	84.8	84.8	84.7	84.7	84.7	84.7	84.9	85.2	85.4	85.4	84.8	86.0	85.2
Sept. 10-16	84.7	85.4	83.7	84.1	84.1	84.1	84.2	84.3	84.1	84.3	84.6	84.6	84.6	84.6	84.5	84.1	85.0	84.4
Sept. 17-23	84.4	85.3	83.7	83.7	83.7	83.9	83.8	83.5	83.6	83.8	83.9	83.9	83.8	83.8	83.2	81.9	82.8	81.9
Sept. 24-30 [11]	84.4	85.8	83.7	84.0	84.2	84.4	84.3	84.2	84.1	84.1	84.4	84.6	84.7	84.7	84.7	84.0	85.7	85.5
Nov. 12-18	79.8	80.2	79.0	80.2	80.4	80.5	80.5	80.5	80.5	80.5	80.4	80.3	80.0	79.4	78.7	72.7	78.3	74.0
Nov. 19-25	78.2	79.9	77.6	80.1	80.2	80.3	80.4	80.4	80.4	80.4	80.3	80.2	80.1	79.8	78.7	71.6	77.7	71.9
Nov. 26-Dec. 2	74.8	78.5	74.4	79.0	79.2	79.2	78.9	78.5	78.1	78.0	78.0	77.8	77.7	77.5	77.4	68.3	76.9	68.4
Dec. 3-9	76.5	79.1	76.4	79.4	79.9	79.7	79.1	78.6	78.6	78.0	77.5	77.3	77.4	77.3	77.0	75.4	77.8	76.0
Dec. 10-16	75.4	77.6	75.0	78.6	79.0	78.6	78.2	77.5	76.8	76.1	75.4	75.6	75.7	75.8	76.0	67.9	75.2	69.5
Dec. 17-23	76.8	77.7	76.0	78.3	78.5	78.6	77.9	77.3	77.1	74.7	74.6	74.7	74.7	74.7	75.0	70.6	74.3	71.2
Dec. 24-31	74.5	77.4	73.6	77.8	78.0	78.1	78.3	78.1	77.5	76.0	74.3	74.0	73.5	73.3	73.0	65.0	72.6	65.4
1929																		
Jan. 1-7	74.5	76.9	74.8	77.4	77.5	77.6	77.7	77.6	77.3	77.2	77.2	77.0	75.6	74.3	74.3	66.4	73.8	66.7
Jan. 8-14 [12]	75.2	77.0	75.7	77.3	77.3	77.3	77.4	77.4	77.3	77.0	76.9	76.7	76.4	75.4	73.9	68.5	73.4	71.5
Feb. 19-25	78.0	79.3	77.8	77.6	77.8	77.8	77.8	77.7	77.8	77.9	77.8	77.5	76.8	76.2	75.6	75.5	78.2	77.8
Feb. 26-Mar. 3	78.6	78.9	77.9	77.7	77.9	78.1	78.2	78.2	78.1	78.0	77.9	77.7	77.4	76.7	76.0	76.0	78.9	77.9
Mar. 4-10	77.3	78.2	76.0	77.2	77.4	77.6	77.6	77.6	77.1	75.9	74.6	74.1	73.9	73.9	73.6	72.8	75.2	74.5
Mar. 11-17	77.2	77.7	76.8	77.2	77.6	77.7	77.9	77.8	77.6	77.1	75.9	74.0	73.5	73.9	73.8	73.4	75.4	74.1
Mar. 18-24	79.2	80.2	78.5	78.9	79.0	79.2	79.2	79.1	78.5	77.4	76.0	76.0	75.8	75.9	76.2	75.7	77.6	77.0
Mar. 25-31	79.8	80.7	79.0	78.9	79.1	79.2	79.4	79.4	79.4	79.2	78.3	76.7	67.8	77.4	78.0	79.1	82.2	81.6
Apr. 1-7	79.3	80.2	78.9	78.9	79.0	79.0	79.2	79.4	79.4	79.4	79.2	78.8	78.0	77.0	77.0	77.1	79.1	80.2
Apr. 8-14	79.6	80.7	79.2	79.5	79.8	79.8	79.9	80.1	80.3	80.3	80.2	80.1	79.5	78.8	78.4	78.8	82.4	80.4
Apr. 15-21	80.3	81.3	79.6	79.5	79.5	99.4	79.3	79.3	79.3	79.2	79.1	79.0	78.8	78.2	77.3	75.5	78.1	77.5
Apr. 22-28	80.3	81.8	79.8	79.9	80.1	80.3	80.4	80.4	80.2	79.9	79.8	79.7	79.4	79.0	78.8	79.1	82.2	81.1
Apr. 29-May 5	81.0	82.8	80.3	80.7	80.8	80.8	80.7	80.6	79.9	79.5	79.2	79.2	79.1	79.0	79.1	78.4	82.2	81.5
May 6-12	81.3	82.8	80.4	80.2	80.3	80.3	80.4	80.4	80.4	80.4	80.2	79.7	79.6	79.5	79.7	80.2	82.9	81.8
May 13-19	80.7	82.0	79.0	79.6	80.0	80.3	80.6	80.7	80.7	80.7	80.6	80.4	80.2	79.9	79.6	79.6	81.3	81.3
May 20-26	81.6	82.9	80.6	81.1	81.6	81.9	81.8	81.8	81.8	81.8	81.7	81.5	81.1	80.8	80.8	81.2	84.1	83.3
May 27-June 2 [13]	82.2	83.1	80.1	80.7	81.0	80.9	81.0	81.0	81.1	81.2	81.4	81.3	81.2	80.9	80.9	80.7	82.2	82.5
June 17-23 [14]	82.5	84.8	81.5	82.3	82.5	82.6	82.7	82.8	82.8	82.6	82.4	82.2	81.9	81.9	81.9	82.2	84.3	84.1
July 1-7 [15]	84.0	86.4	82.6	83.0	83.2	83.3	83.4	83.6	83.6	83.7	84.0	84.1	84.2	84.2	84.2	83.8	90.0	89.0
Aug. 12-18	84.6	86.7	83.9	84.5	84.6	84.7	84.6	84.7	84.8	85.0	85.2	85.2	85.3	85.5	85.7	85.6	88.9	88.3
Aug. 19-25	83.6	85.8	82.2	83.1	83.8	84.0	83.9	83.9	83.8	83.8	83.6	83.6	83.7	84.0	84.1	84.3	86.0	85.3
Aug. 26-Sept. 2	83.0	83.9	82.5	83.1	83.4	83.5	83.6	83.5	83.4	83.3	83.3	83.5	83.5	83.4	83.2	82.3	84.1	83.1
Sept. 3-9	84.0	84.7	83.0	83.4	83.4	83.6	83.5	83.4	83.4	84.3	83.3	83.5	83.4	83.4	83.4	83.4	85.4	84.8
Sept. 10-16	84.0	84.9	83.4	83.5	83.5	83.6	83.5	83.6	83.6	83.6	83.5	83.7	84.0	84.1	84.1	84.0	85.4	84.5
Sept. 17-23	84.0	85.9	83.2	83.6	83.8	83.8	83.7	83.6	83.5	83.4	83.4	83.8	83.9	84.0	84.0	84.0	86.0	85.7
Sept. 24-30	84.2	85.2	83.2	83.3	83.4	83.3	83.2	82.9	82.6	82.7	83.1	83.4	83.1	83.0	82.9	83.1	84.9	84.5
Oct. 1-7	85.0	85.5	83.0	82.8	82.7	82.8	82.8	82.8	82.6	81.8	81.6	81.6	81.6	80.9	81.3	80.0	81.5	80.5
Oct. 8-14	83.0	83.6	81.9	82.1	82.0	81.9	82.0	82.1	82.2	82.1	81.8	81.1	79.5	79.6	79.7	78.0	79.4	78.2
Oct. 15-21 [16]	82.5	83.8	81.2	81.4	81.4	81.5	81.4	81.2	81.5	81.6	81.2	79.9	78.7	78.9	78.6	76.7	77.6	77.1
Nov. 19-25	80.5	80.1	79.9	80.5	80.8	80.9	80.9	81.0	81.0	80.9	80.9	80.7	80.1	79.5	78.3	75.2	76.8	75.3
Nov. 26-Dec. 2	80.8	81.8	80.1	80.6	80.8	81.0	81.0	81.1	81.1	81.0	80.6	79.2	77.7	77.7	77.8	76.6	78.0	77.2
Dec. 3-9	79.1	80.1	78.6	79.8	79.8	79.7	79.6	79.6	79.6	79.7	79.3	77.2	76.3	75.8	74.9	67.6	74.2	71.9
Dec. 10-16	79.4	79.9	78.9	79.6	79.5	79.5	79.5	79.5	79.4	79.6	79.6	79.2	78.6	77.4	76.8	73.4	76.8	74.0
Dec. 17-23	77.2	78.5	75.7	78.6	78.8	78.9	79.0	79.0	78.8	77.0	75.2	73.6	75.2	75.6	75.0	66.6	70.0	67.8
Dec. 24-31	76.6	77.5	74.0	78.2	78.3	78.3	78.3	78.2	77.9	77.0	74.8	73.7	73.1	73.4	73.9	61.6	73.5	63.6
Jan. 1-7	75.8	77.7	75.1	77.8	78.0	78.1	78.0	78.1	78.2	78.3	78.1	77.5	76.4	76.1	74.3	68.8	73.1	69.5
Jan. 8-14	75.8	77.4	75.5	77.6	77.8	77.7	77.7	77.9	78.1	78.2	77.7	77.0	76.8	76.5	75.7	70.4	75.7	70.1
Jan. 15-21	77.9	77.8	76.4	78.0	78.4	78.7	79.0	79.0	78.8	78.3	77.8	76.9	74.4	74.0	74.8	74.2	75.4	74.1
Jan. 22-28	77.9	78.8	77.3	78.0	78.4	78.6	78.6	78.7	78.7	78.5	78.4	77.9	76.9	76.0	75.6	74.0	75.3	74.1
Jan. 29-Feb. 4	76.3	77.3	76.0	77.8	77.8	77.9	77.8	77.7	77.8	77.8	77.6	76.4	75.4	74.2	74.0	70.0	73.0	70.8
Mar. 11-17	77.6	79.4	77.2	77.7	77.6	77.5	77.9	77.8	77.6	75.0	72.2	73.3	73.7	74.7	74.9	74.1	76.6	74.1
Mar. 18-24	78.7	80.1	78.2	78.6	78.9	79.1	79.3	79.1	78.2	77.5	76.6	75.8	75.5	75.7	76.0	75.5	78.6	77.7
Mar. 25-31	78.6	79.3	78.0	78.2	78.1	78.1	78.2	78.3	77.9	77.2	76.2	74.7	74.4	74.2	74.2	72.7	75.4	73.8
Apr. 1-7	78.4	79.4	77.7	77.9	77.8	77.8	78.0	78.3	78.3	78.2	78.0	76.8	75.9	75.7	75.0	74.0	76.9	76.6
Apr. 8-14	78.6	79.3	77.4	77.7	77.9	77.9	77.9	78.0	78.0	77.6	76.4	75.4	75.0	74.6	74.5	73.2	75.3	73.7
Apr. 15-21	78.7	80.5	77.9	78.2	78.5	78.7	78.8	79.1	79.3	79.2	78.8	78.5	78.2	77.0	76.2	76.3	80.4	78.8
Apr. 22-28	79.5	81.0	78.6	79.1	79.3	79.5	80.0	80.2	80.1	79.5	79.0	78.4	78.4	78.3	78.1	77.9	79.6	79.2
Apr. 29-May 5	81.0	82.9	79.3	79.8	79.9	80.0	80.3	80.3	79.9	78.8	78.3	78.3	78.7	78.6	79.0	79.1	81.3	80.7
May 6-12	81.2	82.4	79.2	79.5	79.9	80.3	80.5	80.7	80.6	80.4	79.7	79.2	78.9	78.7	78.7	79.6	81.0	80.7
May 13-19	82.0	84.2	80.8	81.3	81.6	81.7	81.6	81.8	82.0	81.9	81.6	81.3	81.0	80.6	80.4	80.7	85.2	84.3
May 20-26	82.2	83.5	80.0	80.5	81.1	81.7	82.1	82.4	82.6	82.5	82.6	82.6	82.5	82.4	82.0	81.1	84.5	84.3
May 27-June 2	80.9	82.2	80.2	81.3	81.9	82.2	82.3	82.2	82.1	81.9	81.7	81.6	81.5	81.5	81.4	81.0	82.8	83.4
June 3-9	81.9	83.3	81.3	81.5	81.3	81.2	81.3	81.3	81.1	80.7	80.5	80.3	79.7	79.7	79.5	78.5	79.5	78.7

[10] Aug. 19 to Sept. 2, 1928. No record; ship in port.
[11] Oct. 1 to Nov. 11, 1928. No record; ship in port.
[12] Jan. 15 to Feb. 18, 1929. No record; ship in port.
[13] June 3 to June 16, 1929. No record; ship in port.
[14] June 24 to June 30, 1929. No record; ship in port.
[15] July 8 to Aug. 11, 1929. No record; ship in port.
[16] Oct. 22 to Nov. 18, 1929. No record; ship in port.

TABLE 2.—*Average weekly temperature values by quarters and halves across the Straits of Florida, July, 1928, to February, 1930*

	Key West-Habana						Habana-Key West					
	1	2	3	4	N.	S.	S.	N.	4	3	2	1
1928												
July 8-14	83.6	83.4	83.0	83.3	83.5	83.2	83.4	84.0	83.5	83.3	83.9	84.1
July 15-21	83.9	84.2	83.8	83.0	84.1	83.5	83.6	84.4	82.9	83.9	84.4	84.2
July 22-28	84.8	85.2	84.8	84.0	85.0	84.7	85.1	86.2	84.4	85.3	86.2	86.1
July 29-Aug. 4	85.6	85.4	84.9	84.4	85.5	84.7	84.9	85.9	84.5	85.1	85.8	86.0
Aug. 5-11 [1]	85.1	85.1	84.7	84.8	85.1	84.7	85.1	85.4	85.1	85.2	85.5	85.3
Sept. 3-9	85.1	84.6	84.7	84.4	84.8	84.7	84.7	85.0	84.5	84.8	84.7	85.3
Sept. 10-16	84.4	84.4	84.1	84.1	84.4	84.1	84.2	84.6	84.1	84.2	84.5	84.6
Sept. 17-23	83.5	83.5	83.6	83.6	83.6	83.6	83.7	83.8	83.8	83.6	83.9	83.6
Sept. 24-30 [2]	84.0	83.7	83.9	84.0	83.8	84.0	84.2	84.5	84.2	84.2	84.4	84.7
Nov. 12-18	79.3	80.5	80.7	80.6	80.1	80.7	80.5	80.1	80.4	80.5	80.4	79.3
Nov. 19-25	79.4	80.2	80.2	80.0	80.0	80.1	80.4	80.1	80.2	80.4	80.3	79.5
Nov. 26-Dec. 2	77.6	77.9	78.7	79.1	77.9	78.8	78.8	77.8	79.2	78.5	78.0	77.5
Dec. 3-9	77.0	76.8	78.1	79.5	76.9	78.6	79.2	77.5	79.6	78.8	77.5	77.2
Dec. 10-16	75.6	75.4	77.3	78.9	75.5	78.0	78.0	75.7	78.7	77.5	75.7	75.8
Dec. 17-23	75.0	75.2	77.0	78.3	75.1	77.5	77.9	74.7	78.5	77.4	74.7	74.8
Dec. 24-31	73.4	74.5	78.0	77.9	74.0	78.0	78.0	74.2	78.0	77.9	74.8	73.3
1929												
Jan. 1-7	74.2	77.0	77.4	77.4	76.2	77.4	77.5	76.3	77.5	77.5	77.1	74.7
Jan. 8-14 [3]	75.1	76.9	77.2	77.2	76.5	77.2	77.3	76.5	77.3	77.3	76.9	75.2
Feb. 19-25	75.6	77.5	77.5	77.5	76.8	77.6	77.8	77.2	77.8	77.8	77.8	76.2
Feb. 26-Mar. 3	76.8	77.6	77.6	77.5	77.4	77.6	78.1	77.5	77.9	78.1	77.9	76.7
Mar. 4-10	73.8	75.0	77.4	77.1	74.5	77.3	77.4	74.5	77.4	77.4	74.9	73.8
Mar. 11-17	73.0	74.4	77.6	77.4	73.8	77.6	77.7	74.9	77.5	77.8	75.6	73.7
Mar. 18-24	75.4	75.2	78.2	78.5	75.2	78.3	79.0	76.2	79.0	78.9	76.5	76.0
Mar. 25-31	76.4	77.8	79.1	78.9	77.1	79.0	79.3	77.7	79.1	79.4	78.1	77.4
Apr. 1-7	77.4	79.1	79.0	78.7	78.5	78.9	79.2	78.5	78.9	79.3	79.1	77.3
Apr. 8-14	78.2	79.4	79.3	79.0	79.0	79.2	80.0	79.8	79.7	80.1	80.2	78.9
Apr. 15-21	78.0	79.1	79.2	79.3	78.9	79.2	79.4	78.9	79.5	79.3	79.1	78.1
Apr. 22-28	78.3	78.6	79.4	79.5	78.5	79.5	80.3	79.6	80.1	80.3	79.8	79.1
Apr. 29-May 5	78.3	78.4	80.0	70.3	78.3	80.1	80.6	79.2	80.8	80.4	79.3	79.0
May 6-12	79.2	79.7	80.2	80.1	79.4	80.2	80.4	79.9	80.3	80.4	80.1	79.6
May 13-19	79.6	80.3	80.3	79.7	80.1	80.2	80.5	80.4	80.0	80.7	80.5	79.9
May 20-26	80.7	81.3	81.2	80.9	81.1	81.1	81.8	81.4	81.6	81.8	81.7	80.9
May 27-June 2 [4]	80.6	81.2	80.8	80.7	81.0	80.8	81.0	81.2	80.9	81.0	81.3	81.0
June 17-23 [5]	81.6	82.1	82.3	81.9	82.0	82.1	82.7	82.2	82.5	82.8	82.4	81.9
July 1-7 [6]	83.3	83.0	83.0	82.8	83.1	82.9	83.4	84.0	83.1	83.5	83.9	84.2
Aug. 12-18	84.7	84.4	84.2	84.2	84.5	84.2	84.7	85.2	84.6	84.7	85.1	85.5
Aug. 19-25	83.6	83.3	83.6	83.2	83.4	83.6	83.9	83.8	83.6	83.8	83.7	83.9
Aug. 26-Sept. 2	82.9	82.8	83.1	83.0	82.9	83.1	83.5	83.4	83.3	83.5	83.4	83.4
Sept. 3-9	82.8	82.8	83.2	83.2	82.7	83.2	83.5	83.4	83.4	83.4	83.4	83.4
Sept. 10-16	83.5	83.1	83.2	83.3	83.3	83.3	83.6	83.8	83.5	83.6	83.6	84.1
Sept. 17-23	83.2	82.8	82.8	83.0	82.9	82.9	83.7	83.7	83.7	83.6	83.5	84.0
Sept. 24-30	82.8	82.8	82.7	83.1	82.9	82.9	83.1	83.1	83.3	82.8	83.1	83.0
Oct. 1-7	81.4	81.3	82.7	83.0	81.4	82.8	82.7	81.5	82.7	82.7	81.7	81.3
Oct. 8-14	79.4	81.3	82.1	82.1	80.4	82.1	82.0	80.8	82.0	82.1	81.7	79.6
Oct. 15-21 [7]	78.8	81.0	81.3	81.3	80.1	81.3	81.4	80.1	81.4	81.4	81.0	78.7
Nov. 19-25	79.8	80.9	80.8	80.7	80.5	80.8	80.9	80.4	80.8	80.9	80.8	79.3
Nov. 26-Dec. 2	77.5	80.6	80.9	80.6	79.3	80.8	81.0	79.2	80.7	81.1	80.3	77.7
Dec. 3-9	75.4	79.4	79.7	79.7	77.9	79.6	79.7	77.7	79.8	79.6	78.7	75.6
Dec. 10-16	77.0	79.4	79.5	79.4	78.5	79.5	79.5	78.9	79.5	79.5	79.4	77.6
Dec. 17-23	75.2	75.0	78.8	78.8	75.2	78.9	78.9	75.3	78.8	78.9	75.3	75.2
Dec. 24-31	73.7	75.4	78.2	78.3	74.7	78.3	78.2	74.4	78.3	78.1	75.2	73.5
1930												
Jan. 1-7	75.5	78.1	78.1	77.9	77.4	78.0	78.1	77.3	77.9	78.1	78.0	75.6
Jan. 8-14	76.1	77.7	77.8	77.7	77.1	77.8	77.8	77.2	77.7	77.9	77.6	76.3
Jan. 15-21	74.6	78.0	78.6	78.0	76.8	78.4	78.8	76.3	78.4	79.0	77.7	74.4
Jan. 22-28 [8]	75.8	78.0	78.5	78.3	77.3	78.4	78.6	77.5	78.3	78.7	78.2	76.1
Jan. 29-Feb. 4	74.2	77.1	77.8	77.8	76.1	77.8	77.8	76.2	77.8	77.8	77.2	74.5
Mar. 11-17 [9]	74.0	73.9	77.6	77.6	73.9	77.6	77.7	73.8	77.6	77.8	74.1	74.4
Mar. 18-24	74.9	75.2	77.8	78.3	75.0	78.1	78.9	76.2	78.9	78.9	76.7	75.7
Mar. 25-31	73.5	75.6	78.2	78.3	74.8	78.1	78.1	75.3	78.1	78.1	76.1	74.2
Apr. 1-7	74.9	77.5	77.9	77.6	76.6	77.8	78.0	76.9	77.8	78.2	77.7	75.5
Apr. 8-14	74.1	74.7	77.8	77.7	74.3	77.8	77.9	75.8	77.8	78.0	76.5	74.7
Apr. 15-21	75.6	77.6	78.5	78.2	76.9	78.4	78.9	78.3	78.5	79.1	78.8	77.2
Apr. 22-28	78.0	78.4	79.6	79.1	78.3	79.4	79.8	78.7	79.3	80.1	78.9	78.3
Apr. 29-May 5	78.1	77.8	79.5	79.4	77.9	79.5	80.1	78.6	79.9	80.2	78.5	78.7
May 6-12	78.3	79.4	80.3	79.7	78.9	80.1	80.4	79.4	79.9	80.6	79.8	78.7
May 13-19	79.7	80.9	80.8	80.8	80.4	80.8	81.7	81.3	81.5	81.8	81.6	80.7
May 20-26	81.9	81.9	81.8	81.2	82.0	81.7	82.0	82.5	81.1	82.3	82.6	82.3
May 27-June 2	81.0	81.0	81.4	81.7	81.0	81.5	82.1	81.6	81.8	82.2	81.7	81.5
June 3-9	79.5	80.1	80.7	81.0	79.9	80.8	81.2	80.2	81.3	81.2	80.5	79.6

[1] Aug. 12 to Sept. 2, 1928. No record; ship in port.
[2] Oct. 1 to Nov. 11, 1928. No record; ship in port.
[3] Jan. 15 to Feb. 18, 1929. No record; ship in port.
[4] June 3 to June 16, 1929. No record; ship in port.
[5] June 24 to June 30, 1929. No record; ship in port.
[6] July 8 to Aug. 11, 1929. No record; ship in port.
[7] Oct. 22 to Nov. 18, 1929. No record; ship in port.
[8] Feb. 5 to Mar. 10, 1930. No record; ship in port.
[9] Record for one day only in this week.

TABLE 3.—*The per cent the actual agreements of temperature trends are of the maximum possible agreements*

	Per cent of agreements		
	Up trends	Down trends	All trends
Maximum air temperature (day):			
Key West harbor	86	84	85
North half of Straits	79	84	82
South half of Straits	79	88	84
Minimum air temperature (night):			
Key West harbor	68	76	72
North half of Straits	61	72	67
South half of Straits	62	64	63
Mean air temperature (day):			
Key West harbor	86	84	85
North half of Straits	79	81	80
South half of Straits	74	81	78
Mean air temperature (night):			
Key West harbor	86	85	85
North half of Straits	72	77	75
South half of Straits	69	72	71
Key West harbor (day): North half of Straits	74	80	77
Key West harbor (night): North half of Straits	72	77	75
North half of Straits (day): South half of Straits	63	74	70
North half of Straits (night): South half of Straits	56	80	71
Habana harbor (day):			
Key West harbor	73	81	77
South half of Straits	58	71	65
Maximum air temperature	59	67	63
Maximum air temperature (night):			
Key West harbor	86	88	87
North half of Straits	72	80	77
South half of Straits	75	68	71

TABLE 4.—*Percentage of relationship, being the agreements of trend in excess of expectation by chance, expressed in per cent of the difference between chance and perfect agreement*

	Per cent in excess of chance agreements for—		
	Up trends	Down trends	All trends
Maximum air temperature (day):			
Key West harbor	75	67	71
North half of Straits	61	63	62
South half of Straits	61	71	66
Minimum air temperature (night):			
Key West harbor	41	48	44
North half of Straits	29	29	29
South half of Straits	31	25	28
Mean air temperature (day):			
Key West harbor	74	65	69
North half of Straits	63	56	59
South half of Straits	53	54	54
Mean air temperature (night):			
Key West harbor	74	66	70
North half of Straits	50	42	46
South half of Straits	44	39	42
Key West harbor (day): North half of Straits	52	54	53
Key West harbor (night): North half of Straits	49	42	45
North half of Straits (day): South half of Straits	39	38	38
North half of Straits (night): South half of Straits			
Habana harbor (day):	30	50	40
Key West harbor	46	60	53
South half of Straits	16	32	22
Maximum air temperature	18	31	24
Maximum air temperature (night):			
Key West harbor	75	74	74
North half of Straits	49	50	49
South half of Straits	54	33	42

TABLE 5.—*The percentage of cases in which similar trends follow each other from week to week, the percentage of cases when such is not a fact, and the percentage of cases when the trend is steady from week to week*

	Per cent of continuity of trend	Per cent of discontinuity of trend	Per cent of steady trend
Maximum air temperature	50.0	45.2	4.8
Minimum air temperature	42.9	52.4	4.8
Mean air temperature	50.0	47.6	2.4
Key West harbor day temperature	38.1	57.1	4.8
Key West harbor night temperature	40.5	59.5	0.0
North half of Straits day temperature	52.4	40.5	7.1
North half of Straits night temperature	57.1	38.1	4.8
South half of Straits day temperature	47.6	47.6	4.8
South half of Straits night temperature	50.0	21.4	28.6
Habana Harbor day temperature	33.3	52.3	14.4

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REFLECTIVITY OF DIFFERENT KINDS OF SURFACES

By HERBERT H. KIMBALL and IRVING F. HAND

The reflection measurements and notes given in Table 2 were made by Mr. Hand while a passenger in an Army airplane, using the same photometer that was employed in obtaining the measurements given in the REVIEW, July, 1929, volume 57, pp. 291–295. The object of these flights was to measure the albedo, or the reflection coefficient for different kinds of surfaces under winter conditions.

On account of the cold, it was important that the photometer be read with minimum exposure of the observer to the wind. It was therefore necessary to reverse the position of the graduated spur wheel, *J*,[1] so that it could be read from above. In this new position the diameter of the projection of the iris opening from the white wedge, as read by the glass scale furnished with the instrument, increases with the reading of the photometer dial instead of decreasing as formerly. Compare in Table 1, calibration readings Nos. 3, 4, 5, and 6, made after the change, with Nos. 1 and 2, made before the change. In reading tenths of divisions on dial *K*,[1] it is now necessary to take the compliment of the reading instead of the direct reading.

TABLE 1.—*Iris diaphragm calibration—Photometer Munro No. 3*

Reading of photometer dial	Diameter of projection of iris from white wedge on glass scale in connection with outside of large window—iris closing					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
	Centimeters	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*
20	1.48	1.51				
21	1.36	1.36				
22	1.20	1.26				
23	1.10	1.12				
24	.96	1.01				
25	.84	.88				
26	.73	.73				
27		.59				
27.5		.53				
28.0		.46				
28.2		.41				
15			1.66		1.63	1.64
14			1.52		1.51	1.51
13			1.41		1.38	1.40
12			1.30		1.26	1.28
11			1.17		1.14	1.16
10			1.04	1.050	1.01	1.04
9			.91	.920	.88	.92
8			.79	.790	.75	.80
7			.64	.660	.63	.67
6			.51	.505	.51	
5.8				.485		
5.6				.465		
5.4				.420		
5.2				.405		
5.0				.380	.39	
4.8				.350		
4.6				.320		
4.4				.290		
4.2				.260		
4.0				.240		
3.8				.210		
3.6						

No. 1.—Mean of two readings each by Messrs. Kimball and Hand, Jan. 11, 1930.
No. 2.—Mean of one reading each by Messrs. Kimball and Hand, Jan. 11, 1930, paper separator in place holding neutral glass filter. This calibration for use with measurements over snow.
No. 3.—First calibration after dial was reversed. Mean of readings by Messrs. Kimball and Hand on Jan. 15, 1930.
No. 4.—Readings same date by same observers but with neutral glass and paper washer in place. For use with snow observations.
No. 5.—Check readings made Feb. 7, 1930.
No. 6.—Check readings made May 12, 1930.

[1] Richardson, L. F. Report on photometers for a survey of the reflectivity of the earth's surface. Union Géodésique et Géophysique Internationale, Section de Météorologie. Troisième Assemblée Générale. Prague, 1927. Cambridge, Eng., 1928.

Cloud conditions during the winter of 1929–30 were seldom favorable for reflectivity measurements. On days when there was a cloud cover of uniform thickness precipitation generally occurred before a flight could be made. Fortunately, February 1, following the only considerable snow storm of the winter (11.5 inches on January 30), was cloudy during the morning, and by flying north a snow cover that had been but little affected by the sunshine of January 31 was found. The results of the flight are given in Table 2, flight No. 1.

TABLE 2.—*Flight No. 1: Took off from Bolling Field at 10 a. m., February 1, 1930: returned at noon. Lieutenant Willis piloting OH-1 Douglass plane, "The Alabama." Ground covered with snow, which was 11.5 inches deep at Washington at 8 p. m. of January 30, 9.5 inches on January 31, and 5.5 inches on February 1. Neutral-glass filter transmitting 49 per cent ± 1 per cent covers sky window*

Ratio $\frac{A_s}{A_g}$	Reflection (unit=0.001)	Height above sea level (feet)	Filter	Position and notes
166	423	1,000	None	Over St. Elizabeths.
243	620	1,500	None	Park in Washington; very smoky and hazy.
196	500	1,500	None	Hyattsville, Md.
308	786	1,500	None	White field.
97	247	1,500	None	Forest.
291	742	1,500	None	White field.
338	862	1,500	None	Very white field.
349	890	1,500	None	Do.
283	722	1,500	Green	White field.
49	125	1,500	None	Dark forest.
36	92	1,500	None	Very dark forest.
291	742	2,000	None	White field.
248	633	2,000	Geeen	White field (near Sugar-Loaf Mountain).
299	763	2,500	None	Large white field.
54	138	2,500	None	Forest.
275	702	3,000	None	White field.
147	375	3,000	Red	White field; difficult setting.
38	97	3,000	None	Forest.
294	750	4,000	None	White field.
86	219	4,000	None	Forest; too cold at this height.
38	97	2,000	None	Baltimore; very smoky beneath.
38	97	2,000	None	Chesapeake Bay; smooth surface.
275	702	2,000	None	White field.

NOTE.—To obtain the reflection coefficient, or albedo, the ratio A_s/A_g has been multiplied by 1.25/.49=2.55, where the factor 1.25 makes allowance for the fact that the sky window admits light to the photometer from a sky area near the zenith, which is the brightest point in a completely overcast sky. The factor 0.49 is the transmission of the neutral glass screen.

The designation "White field" simply means a patch of snow large enough to give time in passing over it for an accurate setting of the photometer.

This was the first time that the plane had been taken out since it had been given a light overhauling. The flight was therefore serving a dual purpose—for observational work, and for a test flight. This latter necessitated at times speed in excess of 150 miles per hour with attendant vibrations, particularly of the photometer; but since this speed was maintained for brief periods only, it did not interfere with observations.

The photometer had been recalibrated with its dial changed from the lower to the upper side. Without this change it would have been impossible to read the instrument; in fact, with the heavy clothing needed for protection from the extreme cold, it would have been impossible to have even gotten into the plane with the

photometer as originally mounted, with half of it projecting into the cockpit.

The neutral filter was used during the entire series owing to the difficulty in removing it during flight.

Weather conditions.—Upon arrival at Bolling Field the sky conditions were ideal, but as it was inspection day, and the plane was still undergoing repairs, some hours elapsed before we were able to take off. Good conditions prevailed for 10 minutes, after which the sun came out. We headed north and within half an hour were again under a totally cloudy sky; in fact, the best sky we have yet had for observing. We turned back near the Maryland-Pennsylvania State line, returning by way of Baltimore, and obtained some measurements over Chesapeake Bay.

Our attempt to locate pine or evergreen forests of large enough area for observational work was futile, so we had to be satisfied with deciduous trees. We were fortunate in locating many large open fields completely snow covered. The composite view from the air of mixed terrain (forests, fields, streams, cities, and towns, etc.) following a heavy snow storm, did not present as white a surface as had been anticipated due to the darkening effect of large forest areas.

Observations were made at various heights, but the temperature was so low at 4,000 feet and the wind so strong that readings at this height were soon abandoned.

Very few measurements of the various components of light were obtained. The condensation of moisture on the inside of the observer's goggles, together with the filtration of the light beam by the color screens, diminished the illumination intensity to a point where photometric settings were of doubtful value.

TABLE 2.—*Flight No. 2. Took off from Bolling Field at 11 a. m., February 5, 1930; returned at noon. Lieutenant Willis piloting OH-1 Douglass plane, "The Alabama"*

Ratio $\frac{A_s}{A_g}$	Reflection (unit=0.001)	Height above sea-level (feet)	Filter	Position and notes
47	59	1,000	None	Washington, D. C.
38	48	1,000	None	Grassy fields.
34	42	1,000	None	Forest.
120	150	1,000	None	Field; some snow.
65	81	1,000	None	Forest; some snow.
29	36	1,000	None	Pine forest; no snow.
86	108	1,000	None	Deciduous forest; some snow.
48	60	1,000	None	Deciduous forest; no snow.
36	45	1,000	None	Grassy fields (greener than would be expected; probably spring wheat).
52	65	1,000	Green	Same kind of field; no snow.
34	42	1,000	Green	Forest on hillside; very little snow.
27	34	2,000	None	Pine forest. Now in Virginia; no snow during remainder of flight.
31	39	2,000	None	Deciduous forest.
35	44	2,000	None	Green fields.
[1] 55	69	10-20	None	Over Potomac River.
44	55	10-20	Green	Do.
83	104	10-20	Red	Do.

[1] Came down low over the river on account of the extreme cold aloft which made reading the photometer unbearable, as my flying suit had been torn open by the wind. It is necessary to lean out of the cockpit when making settings on the photometer and perfect fitting clothing is required to stand the strain. This was by far the coldest of the flights which explains the paucity of readings obtained.

TABLE 2.—*Flight No. 3: Took off from Bolling Field at 11.50 a. m., May 12, 1930; returned at 1.10 p. m. Lieutenant Willis piloting OH-1, Curtis motored plane, "The Nevada"*

Ratio, $\frac{A_s}{A_g}$	Reflection (unit=0.001)	Height above sea level (feet)	Filter	Position and notes
481	60	1,000	None	Green fields.
272	34	1,000	None	Green forest.
289	36	2,000	None	Do.
389	49	2,000	None	Light green forest.
490	61	2,000	Green	Do.
537	67	2,500	Green	Ploughed white fields.
520	65	3,000	Red	Do.
388	48	3,000	Red	Forest.
272	34	3,000	None	Mixed; trees, fields, etc.
358	45	3,000	None	Forest.
509	64	3,000	None	Patuxent River.
351	44	3,000	None	Forest.
466	58	3,000	Green	Do.
596	74	3,000	None	Fields; apparently wheat.
516	64	3,000	Green	Do.
273	34	3,000	None	Chesapeake Bay, near shore.
275	34	3,000	None	Chesapeake Bay; one-half mile out.
291	36	3,000	None	Chesapeake Bay; 1½ miles out.
325	42	3,000	Green	Chesapeake Bay; well out.
317	40	3,000	Green	Do.
315	39	3,000	Green	Do.
359	45	3,000	Red	Do.
359	45	3,000	Red	Do.
363	45	3,000	Red	Do.
278	35	3,000	None	Do.
284	36	3,000	None	Do.
296	37	2,000	None	Do.
300	38	2,000	None	Do.
386	48	2,000	Green	Do.
390	49	2,000	Green	Do.
362	45	2,000	Green	Do.
277	35	2,000	Red	Do.
324	40	2,000	None	Chesapeake Bay, near shore.
532	66	2,000	None	Broken ground; trees, bare ground, etc.
442	55	2,000	None	Patuxent River.
634	79	200	Green	Light green wheat field.
409	51	100	Green	Forest.
1,083	112	100	None	Very white bare ground.

NOTES.—(1) Tried blue filter but had no success, as the light transmitted was too weak to admit of accurate settings.

(2) Bay seemed smooth but close inspection showed presence of white caps. Bay appeared much darker near shore. Headed for the ocean but clear skies made return trip necessary. It is thought, however, that bay measurements closely approximate those over ocean, as the bay is so large at this point and close to the ocean.

(3) Patuxent River appeared to be lighter in color than the bay.

(4) At elevation of 200 feet and less it was impracticable to attempt readings over forests or over green fields with no filter, owing to extreme color difference, which is much greater than at higher levels.

(5) Excellent visibility; Blue Ridge plainly visible from extreme eastern point of flight, an estimated distance of over 100 miles. The individual peaks stood out clearly when flying at a height of 3,000 feet. Visibility to the east was rather poor, due chiefly to clear skies over the ocean.

(6) Altogether the sky conditions during the flight were as good or better than during any other flight. The only interference from uneven sky conditions came at the extreme eastern point of the flight, when observations were discontinued for a few minutes.

(7) Most of the terrain covered was rather broken—that is, alternate small forest areas, wheat fields, ploughed ground, villages, rivers and small streams. There are few large farms, the average size probably not exceeding 100 acres, and each farm itself being broken up into various kinds of surfaces.

(8) Although readings have been recorded at 2,000 feet, the height varies from 1,950 to 2,050 feet owing to bumpy conditions at the 2,000-foot level. Aside from this one bumpy layer, the flying was very smooth, although the usual bumps occurred when flying from over a land surface to over a water surface, or vice versa.

(9) The plane used during this flight is extremely fast; being of a new type recently adopted by the Army. Nevertheless, excellent exposure was obtained with little or no obstruction from plane parts.

The reflection measurements given in Table 2, flight No. 1, over snow-covered fields are in good accord with measurements over similar surfaces made with a pyrheliometer by Kalitin at Sloutzk, near Leningrad (MONTHLY WEATHER REVIEW, February, 1930, vol. 58, p. 59), if we take into account the fact that flight No. 1 was made on the second day following the snowfall, and that in

the meantime in the vicinity of Washington there had been material settlement of the snow. The measurements by Kalitin over bare ground in April and May give much higher values than are given in Table 2, flight No. 2, and this is also true of similar measurements by Ångström using a pyrheliometer (MONTHLY WEATHER REVIEW, November, 1926, vol. 54, p. 453). In explanation of these differences it should be remembered that the Richardson photometer measures the vertical reflection from an area of small angular extent immediately below it, while the pyrheliometer employed by Kalitin and Ångström measures the light received from a full hemisphere. Since newly fallen snow gives an almost perfect matt-surface, it has the same brightness from whatever angle it is viewed. The vertical reflection is the same as the reflection from various angles of incidence. This is not the case with water surfaces, plowed ground surfaces or sod surfaces. The first named becomes nearly a perfect reflector at low angles of incidence, as compared with the low reflection obtained at normal incidence. Fields of growing grain or grass present a deeply pitted surface with the bottoms of the pits poorly illuminated. When viewed at normal incidence it is principally the illumination from the bottom of these pits that is measured, while as the angle of incidence increases the reflecting surfaces present an increasing percentage of leaf surface. For this reason measurements with the pyrheliometer give values of reflection from sod surfaces approaching in value the reflecting power of leaf surfaces as measured by Coblentz and others.

RAINFALL CATCH AS AFFECTED BY DIFFERENT DEPTHS OF FUNNELS IN THE RAIN GAGE

By BENJAMIN C. KADEL

[Weather Bureau, Washington, April 18, 1930]

The standard 8-inch rain gage of the United States Weather Bureau is equipped with a collecting funnel having a vertical wall 2¼ inches deep to the sloping part, then a slope angle of 41½° below the horizontal to the outlet.

From time to time honest doubts as to the sufficiency of the depth of this funnel have been communicated to the instrument division of the Weather Bureau, and in an effort to obtain some facts several comparisons were carried on:

The first comparison was voluntarily undertaken by one of these honest doubters, Mr. C. A. Hurlbutt, cooperative observer, Elk Creek station, Pine Grove, Colo., who was provided by the instrument division with a second gage exactly like his standard, but with the vertical wall of the funnel 6 inches deep as compared with the 2¼-inch standard. Mr. Hurlbutt made readings of both gages daily, May to October, 1923. The total catch in the standard funnel was 23.59 inches and in the funnel with 6-inch wall 23.97, an increase of 1.4 per cent. Of the 97 comparisons made, 78 showed exact agreement between the two gages, 7 showed 0.01 inch more caught in the deeper funnel, 7 showed 0.02 inch more, 1 showed 0.03 inch more, 1 showed 0.05 inch more, while one instance showed 0.03 inch less.

Differences for each rain can not well be expressed in percentages, and it seems needful for a complete understanding to present, as Table I, the tabulated measurements as Mr. Hurlbutt reported them. Wind velocity was not recorded:

Through the cooperation of Dr. Oliver L. Fassig in charge of the San Juan, P. R., station of the Weather Bureau and his assistants a more extended set of comparisons was carried out on the grounds of the San Juan Weather Bureau station. Two standard 8-inch gages, one with vertical wall of funnel 2¼ inches deep, the other with wall 6 inches deep were exposed side by side. Detailed measurements are presented in Table II. The total catch in the 2¼-inch funnel was 47.41 inches and in the 6-inch funnel 47.96 inches, or 1⅛ per cent more. Of the 145 measurements made, 77 showed exact agreement, 23 showed 0.01 inch more for the deeper funnel, 12 showed 0.02 inch more, 5 showed 0.03 inch more, and 1 showed 0.06 inch more, 20 showed 0.01 inch less, 2 showed 0.02 inch less, and 1 showed 0.04 inch less.

TABLE 1.—*Daily catch of rainfall (inches) two 8-inch gages equipped with 2¼-inch and 6-inch funnels, respectively. Elk Creek Station, Pine Grove, Colo.*

	May		June		July		August		September		October	
	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches
1					0.37	0.38	0.75	0.75	0.02	0.02	0.10	0.12
2					.05	.05					.08	.09
3	0.03	0.03	0.20	0.20	.02	.02	.01	.01			.23	.25
4			.02	.02	.01	.01	.11	.13			.64	.67
5	.09	.09	.22	.22			.05	.05	.02	.02	.06	.08
6	.03	.03	.07	.07			.25	.25				
7	.02	.02	.05	.05	.37	.37	.81	.85				
8			.65	.65	.53	.55	.36	.36				
9			2.02	2.02			.26	.26				
10			.10	.10	.21	.21	.05	.05				
11	.04	.04					.45	.45	.02	.02		
12	.08	.08	.02	.02	.30	.30	.32	.32			.68	.68
13	.10	.10							.07	.07	.08	.09
14	.20	.31			.36	.36	.15	.15	.10	.10		
15	.23	.23			.72	.72	.55	.55				
16	.01	.01	.20	.20	1.25	1.30	.34	.34	.03	.03		
17	.03	.03			.54	.54	.25	.27	.12	.12		
18							.04	.04	.43	.47		
19					.29	.29	.42	.43			.01	.01
20	.01	.01			.06	.06	.20	.20				
21	.01	.01	.13	.13	.36	.36	.16	.16				
22	.35	.32					.18	.18				
23	.07	.07					.55	.55	.20	.21	.23	.23
24							.05	.05			1.28	1.28
25	.17	.17			.06	.06	.07	.07			.14	.14
26					.53	.54						
27					.95	.96	.01	.01				
28					.08	.08			.21	.21		
29											.05	.05
30									.04	.04		
31							.06	.06				
Sums	1.56	1.55	3.68	3.68	7.06	7.16	6.45	6.54	1.26	1.31	3.58	3.69

TABLE 2.—*Daily catch of rainfall (inches) two 8-inch gages equipped with 2¼-inch and 6-inch funnels, respectively. San Juan, P. R., May 6, 1924, to March 23, 1925*

	May		June		July		August		September	
	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches
1							0.04	0.04		
2					0.21	0.21	.24	.24		
3					.04	.04				
4					1.22	1.24				
5			0.11	0.11	.08	.08				
6	0.10	0.10			1.23	1.23	.02	.02		
7			.12	.11	.98	.98				
8			.07	.07						
9			.18	.18						
10	.31	.32	.33	.33						
11	1.72	1.78			.06	.06				
12	.33	.32	1.21	1.21	.01	.01				
13	.06	.07	.08	.08	.18	.18				
14	.03	.04	.06	.06	.09	.09				
15	.11	.12								
16	.07	.07								
17	.53	.53	.06	.06						
18	.08	.08								
19	.15	.15	.01	.01						
20	.15	.15			.13	.13				
21			.69	.67	.28	.28				
22			1.66	1.62	1.18	1.19				
23			.14	.15					1.96	2.00
24					.07	.07				
25	.04	.04	.36	.34	.07	.07				
26	.03	.03	.15	.15						
27	.06	.06	.04	.04	.03	.03	.42	.44		
28	.12	.12	.02	.02	.24	.26				
29	.21	.21	.07	.06						
30	.10	.10	.09	.08	.21	.21				
31										
Sums	4.20	4.29	5.45	5.35	6.31	6.36	.72	.74	1.96	2.00

	October		November		December		January		February		March	
	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches	2¼ inches	6 inches
1			1.94	1.93			0.37	0.40			0.22	0.22
2			.15	.15			.12	.13			.02	.03
3					0.41	0.40	.10	.11	0.01	0.01		
4					.25	.25	.36	.36				
5	0.87	0.89	.63	.63	.10	.10	.02	.02				
6	.20	.20	.02	.02	.29	.28	.45	.45	.05	.04		
7							.04	.04			.01	.01
8							.06	.06	.01	.01		
9									.30	.30	.01	.01
10							.36	.37	.94	.98	.06	.05
11			1.21	1.20								
12												
13					.73	.74					.65	.65
14			1.40	1.40					.60	.62	.04	.04
15			.20	.20	.24	.24			.05	.05		
16			.32	.31	.34	.33	.28	.30	.37	.39		
17					.45	.47	.28	.29	.50	.53	.05	.06
18			1.01	1.05	.59	.62			.60	.61	.06	.06
19					.33	.36			.08	.09	.10	.09
20			1.46	1.45	.11	.13	.05	.05	.04	.04	.04	.03
21			2.46	2.50	.29	.31					.08	.08
22			.32	.32	.05	.06	.12	.11	.20	.21	.05	.06
23					.02	.02	.03	.02	.02	.02	.05	.05
24			.31	.31	1.03	1.07			.10	.10		
25					.19	.20						
26					.72	.74	.02	.02				
27					.16	.17	.12	.12				
28					.64	.63						
29					.29	.30	.22	.23				
30					.12	.14	.03	.02				
31					.56	.55	.01	.01				
Sums	1.07	1.09	11.43	11.47	7.91	8.11	3.04	3.11	3.87	4.00	1.44	1.44

A recording anemometer in operation at San Juan makes possible examination of the catch as affected by wind. On nine occasions during which maximum winds 35 to 42 miles an hour were recorded, the catch was 3.55 inches and 3.62 inches, respectively, an increase of 2 per cent for the deep funnel. On 21 occasions with maximum winds 30 to 34 miles an hour, the catch was 5.18 and 5.54, respectively, an increase of less than 7 per cent.

Presentation of all these details is hardly warranted, but Table 3 shows that in moderately windy weather the advantage of the deeper funnel is not completely established. Two occasions, February 16 and 17, show an advantage for the deeper funnel, but the total amount of rainfall is not large, nor are these two occurrences considered conclusive evidence.

TABLE 3.—*Advantage of deeper funnel not completely established*

	Wind		Rainfall, inches		
	24 hours, miles	Maximum miles an hour	2¼-inch funnel	6-inch funnel	Per cent
May 11, 1924	253	15	1.72	1.78	+2
June 22, 1924	206	20	1.66	1.62	−2
Jan. 1, 1925	359	32	.37	.40	+8
Feb. 16, 1925	620	33	.37	.39	+5
Feb. 17, 1925	521	31	.50	.53	+6
			4.62	4.72	+2⅛

The San Juan comparisons include also measurements of the catch in two gages 12 inches in diameter, one being the tipping gage employed by the Weather Bureau for automatic record purposes and equipped with a funnel with rim 3 inches deep, sloping down 45° to the outlet; the other differing only in depth of funnel, which was 8 inches instead of 3. The catch in these two gages is shown in Table 4, to be in close agreement throughout the period, some of the monthly totals being the same for both gages, and the totals for the entire period differing by only six-tenths of 1 per cent. Reference to the individual values, not here presented, show the usual day-to-day differences.

TABLE 4.—*Catch of rainfall, San Juan, P. R.*

1924–1925	12-inch gages		Total	Per cent
	3-inch rim	8-inch rim		
May 6–31	4.17	4.21	+.04	+1
June	5.37	5.35	−.02	0
July	6.33	6.36	+.03	0
August	0.73	0.74	+.01	+1
September	2.00	1.98	−.02	−1
October	1.08	1.08	0	0
November	11.30	11.30	0	0
December	7.95	7.85	−.10	−1
January	2.97	2.89	−.08	−3
February	3.86	3.77	−.09	−2
Mar. 1–24	1.36	1.30	−.06	+4
	47.12	46.83	−.29	−0.6

Recognizing well known uncertainties attending the collection of rainfall, the conclusions to be drawn from these experiments may be stated as follows:

1. Increasing the 3-inch depth of the funnel of the 12-inch gage did not increase the amount of rainfall collected.

2. Increasing the 2¼-inch depth of the funnel of the 8-inch gage increased the amount collected by a little more than 1 per cent, a value within the limits of error.

3. There is no sufficient warrant in the showing made for correction of existing records made with either of the two gages (over 40 years), nor for recommending any change in United States Weather Bureau gages.

4. In the design of a new pattern rain gage the depth of funnel should be somewhat greater than 2¼ inches but need not exceed 3 inches.

It is known that a shallow funnel gage was discontinued many years ago in favor of the present form.

THE PRESENT STATUS OF CORRELATION INVESTIGATION IN METEOROLOGY [1]

By FRANZ BAUR

(Translated by W. W. Reed)

Since merely first attempts at an application of correlation reckoning to the phenomena of daily weather and related problems are made here, this report was limited to those investigations that are, as a rule, in mind when there is discussion of meteorological correlation investigation, that is, to the investigation of weather phenomena and their relations.

These investigations are divided into two groups which are, on the whole, not to be sharply differentiated:

1. Investigations of the relations of weather anomalies to coexistent anomalies in other regions, and
2. Investigations of the relations of weather anomalies to antecedent or subsequent anomalies at the same place or even at another place.

The most comprehensive investigations of the first class are those made by G. T. Walker. According to his view

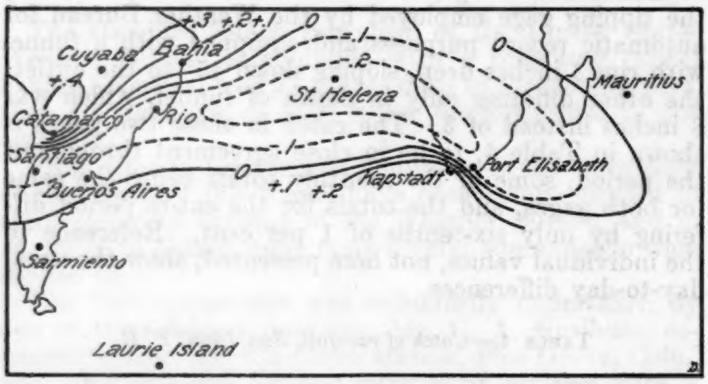


FIGURE 1.—Lines of equal correlation coefficients between January pressure at Laurie Island (South Orkneys) and the coexisting pressure in the high pressure area of the South Atlantic. 1903-1923.

we have on the earth's surface three pressure oscillation systems:

(*a*) The North Atlantic oscillation characterized by negative correlation between the pressure over the Azores and the coexistent pressure over Iceland;

(*b*) The North Pacific oscillation, which appears in a corresponding negative correlation between the air pressure at Honolulu and that over the Aleutian Islands; and

(*c*) The so-called see-saw of the Southern Hemisphere, which consists in a negative correlation between the pressure over the Indian Ocean and that in the South Pacific Ocean, in which, in general, the regions of high pressure in the Southern Hemisphere have a pressure oscillation following the course of that of the South Pacific, while the regions with low pressure in summer have a pressure oscillation paralleling that of the Indian Ocean.

The first two oscillation systems are very evidently connected with that total of current systems that we are accustomed to call the "general atmospheric circulation." This connection comes about in that:

1. The velocity of the west-east current in the temperate zone depends on the amount of the pressure gradient from the subtropical high pressure region to the low pressure region in about latitude 65° N. and;
2. Low pressure near Iceland and low pressure over the Aleutian Islands brings about zonal pressure differences, which make possible the exchange of air masses between the subtropical and the polar regions in adjacent meridional currents.

On the other hand, despite all endeavors devoted to the purpose, there has been thus far no success in fitting the air pressure see-saw of the Southern Hemisphere into the system of the general circulation of that region in the same clear and natural manner. It must be pointed out here that the correlation coefficients characterizing the see-saw are considerably smaller and more changeable from year to year than is the case with the coefficients in the northern oscillation systems, especially that in the North Atlantic.

On theoretical grounds, however, it is probable that meridional pressure compensations exist in the Southern Hemisphere also. At present they can be demonstrated only with very great difficulty, since there are no suitably located observation stations in the pressure trough between 50° and 70° S. The only station here is Laurie Island (South Orkney Islands), from which there is available at present only a short series of observations. The pressure correlations, calculated by myself, for this station with the different stations in the Southern Hemisphere in latitudes 15° to 45° permit the conclusion—as will appear from Figures 1 and 2—that there is a negative correlation of pressure between lower and higher latitudes; and it appears that the central region of the South Atlantic High has the most marked negative pressure correlation with Laurie Island, thus, that in the South Atlantic there exists a pressure compensation system such as we have long recognized in the North Atlantic.

As we delve deeper and deeper into weather phenomena it appears that the so-called "general atmospheric circulation" is a rather complicated system, made up of a whole series of subsystems and that, in the temperate zones especially, the essential part of this general circu-

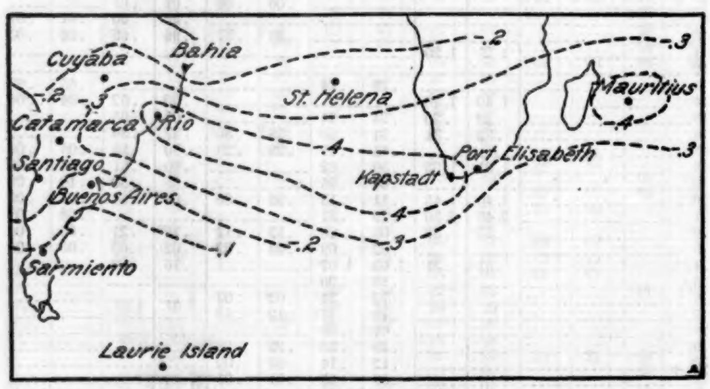


FIGURE 2.—The same except for July instead of January.

lation is not the west current or—more correctly stated—the excess of westerly wind components, but consists in band-like meridional circulations that bring about exchange between subtropical and polar air. In view of this there arises the question as to how far it is correct to speak of a "general atmospheric circulation" in the sense of a homogeneous system with homogeneous oscillations. The question here proposed is most closely connected with another which I have designated as the basic question of macro-meteorology, which can be formulated thus: In the oscillations of intensity in the different current systems, whose sum total we designate as the gen-

[1] *Zeitschrift für Geophysik, Jahrg. 5, Heft 8. 1929.* The paper from which this one is abstracted appears in *Meteorologische Zeitschrift, Heft 2. 1930.*
See also Gilbert T. Walker's discussion of this paper in *Meteorologische Zeitschrift Heft 6, s. 229-231* (in German).

eral atmospheric circulation, are there involved processes which in the main have their basis in themselves, that is, in which a state B is conditioned in greatest part by a preceding state A (atmospheric or hydrospheric), or is the cause of the changes to be sought in greatest part outside the atmospheric mechanism, thus in cosmic influences or, for example, in dust turbidity due to volcanic eruption?

In his *Untersuchung der Schwankungen der allgemeinen Zirkulation* A. Wagner has shown that in the consideration of 10-year average values there appear between different decades systematic differences in air pressure, temperature, yearly temperature amplitude, and precipitation which permit us the inference of changes in the general circulation as a whole and make it appear probable that these changes have their cause in changes in solar radiation. When, however, we make a numerical comparison between the changes found by Wagner in the 10-year mean values and the anomalies that we encounter in the monthly means there is found such a vast difference that there appears to be full warrant for doubt that these anomalies, which determine the actual character of the weather, are caused chiefly by exterior influences and not by inherent conformity to law in the individual current systems.

These inherent laws bring it about that the oscillations in the individual current systems naturally take place not independently and yet not in homogeneous manner. We have confirmation of this in the negative correlation of air pressure over Iceland with coexistent pressure over the Aleutian Islands in winter and spring, also in extremely low correlation (in spring even negative correlation) of pressure over the Azores with that over Honolulu, and again in very low correlation between air pressure over the Azores and over Iceland, too, with the coexistent pressure in the centers of the subtropical high pressure belt in the Southern Hemisphere; in addition even the correlations for annual means likewise show to some extent not even the sign that would be expected with homogeneous oscillation in all parts of the atmospheric circulation. Then, too, the synchronous correlations within the southern high-pressure belt are only small and not systematic.

In good agreement with these facts there stands the additional one that up to the present time no worthwhile relation could be pointed out between cosmic processes, especially oscillations in sunspots, and terrestrial weather phenomena, since if the oscillations in the individual parts of the atmospheric circulation were to be referred, in the main, directly to oscillations in solar radiation then they must appear uniformly in all current systems. G. T. Walker has calculated for a series of individual stations and for entire regions the correlation coefficients of three-month means of air pressure, temperature, and precipitation with the synchronous relative sunspot numbers. With the exception of those for temperature at Batavia and on Samoa, which are negative in all seasons, the correlation values are generally very small. In agreement with this is the fact that in periodogram analyses of the temperature course at points in the temperate zone the amplitude of the 11-year period always proves to be about the same as, or but little greater than, that to be expected. There could be shown no connection between amount of pressure gradient from the Azores to Iceland and the relative sunspot numbers and none between gradient and change in number from month to month. It may be noted, in conclusion, that Clayton's correlations with Abbot's solar constant are either rather low or—in so far as they show worthwhile values—are derived too unsystematically and from too scant material for conclusions of any certainty to be drawn therefrom.

All these facts lead to the conclusion that the oscillations actually occurring in the several circulation systems and the weather anomalies connected with such oscillations can not be explained exclusively by oscillations in the general atmospheric circulation or by outside influences causing the same, and further that it is rather the peculiar laws inherent in the individual current systems and the relations existing between successive weather anomalies that are of deciding significance.

Correlation reckoning is an important aid in the investigation of the relation between non-synchronous weather anomalies in different regions of the earth. But since there is involved in this the determination of statistical relations between antecedent and subsequent phenomena it can be understood that from the beginning there was connected with these investigations the thought of probable attainment, along this way and at some future time, of long-range weather predictions. It is probably due in part to this combination with the idea of a subsequent long-range forecast that the value of these investigations was not always judged objectively; on the one hand it was over-estimated relative to significance in long-range weather forecasting and on the other hand it was underestimated relative to general scientific value.

This pointed criticism has its basis in large part in the fact that the import of the values and the method of correlation calculation were not always correctly recognized and in the further fact that correlation calculation is, on the whole, not yet a fully developed branch of knowledge, but must be elaborated for the problems propounded to it.

The first error relative to correct discernment of the significance of the values was that of being of the opinion that the correlation coefficient shows directly by what fraction of its amount the one variable is contained in the other. As the result of this idea the value of the first relation equations was overestimated since this fraction, or percentage, is given, not by the correlation coefficient, but by the square of that value.

Consequently the requirement is now made that a relation equation intended for use in forecast purposes shall show at the very least a total correlation coefficient or correlation index of 0.71, since only then has there been comprehended in the elements contained in the relation equation at least the half of all influences.

If we consider in this light some relation equations that have become well known hitherto, we recognize that only a small percentage of these satisfy the condition. Out of the twelve relation equations derived by Walker for different regions and seasons with a view to the prediction of precipitation in India only three fulfill the imposed condition. Among these three equations we find, to be sure, one with a total correlation coefficient of 0.94. However, if this equation is considered more closely it is found that in it are contained a series of questionable correlations.

A high total correlation coefficient is still not enough sufficient for the assumption that a relation equation can serve as basis for a forecast. In addition to this it is necessary that the individual relations be stable and real. The investigation of stability and reality of the relations is unconditionally necessary in order that the correlations may be rightly interpreted.

A good example of the fact that even relations showing noteworthy correlations in a period of 50 years may be unstable is given by the relation between air pressure in Argentina from April to June and the following winter temperatures in northwestern Germany, which gives for the period 1874–1923 a coefficient of—0.48. If we go

back to 1858 and calculate the coefficients for 23-year periods, we have:

1858 to 1880	+0.03
1881 to 1903	−.51
1904 to 1923	−.10

The correlation is, therefore, obviously unstable. This result opens the way to suspicion that the numerous other relations connected with the air pressure over South America in the autumn of the Southern Hemisphere, and hitherto considered as dependable, are unstable.

By real correlations we are to understand those in which there comes to light a coherence in the oscillations of two phenomena in contrast to the apparent, "symptomatic" correlations, in which a correlation is simulated by a secular variation either direct or inverse. The remarkable correlations by Groissmayr between the annual precipitation at Charleston and the Nile flood two years later is ovbiously an outstanding symptomatic one, as can be easily proven by the calculation of the Tschuprow divergence coefficient.

In meteorological correlation investigations we must now make the requirement that stability and reality of correlations be investigated in detail. The most important requisite for a wise application of correlation reckoning in meteorology (and in geophysics) is the formulation of a clear and studied statement of the problem in a theoretical manner. The meagerness of the results of previous correlation investigations arises from the fact that these requirements were, for the greater part, not fulfilled.

There are given, in conclusion, some results of the recent investigations of the writer relative to cases of conformity to law found in the air pressure oscillations in the belts of circulation over the North Atlantic Ocean. In strictest adherence to theoretical considerations and calculations, which showed that the air pressure on the middle meridian of belt of circulation oscillates in dependence on the preceding zonal differences in pressure and temperature, there were calculated for the following table the correlation coefficients of the monthly means of zonal pressure and temperature differences with (*a*) the air pressure gradient Ponta Delgada-Iceland from the month under consideration to the next, and (*b*) with the change in air pressure over Iceland in the same period.

Correlation coefficients of the zonal pressure and temperature differences

	I-I/II	II-II/III	III-III/IV	IV-IV/V	V-V/VI	VI-VI/VII	VII-VII/VIII	VIII-VIII/IX	IX-IX/X	X-X/XI	XI-XI/XII	XII-XII/I	Mean
	(*a*) With change in pressure gradient Ponta Delgada-Iceland to the next month (1874-1923)												
Pressure difference:													
Rome-Ponta Delgada	+0.36	+0.48	+0.37	+0.53	+0.59	+0.46	+0.35	+0.32	+0.16	+0.48	+0.21	+0.27	+0.38
Indianapolis-Ponta Delgada	+.42	+.52	+.66	+.56	+.41	+.44	+.48	+.29	+.23	+.46	+.41	+.34	+.44
Haparanda-Stykkisholm	−.39	−.58	−.55	−.58	−.26	−.59	−.58	−.19	−.30	−.43	−.35	−.16	−.41
Jacobshavn-Stykkisholm	−.32	−.45	−.47	−.47	−.06	−.36	−.23	−.31	−.50	−.39	−.44	−.36	−.36
Temperature difference:													
Tromso-West Greenland	−.16	−.42	−.44	−.41	−.21	−.59	−.16	−.43	−.53	−.51	−.30	−.34	−.38
	(*b*) With change in pressure to the next month over Iceland (1874-1923)												
Pressure difference:													
Haparanda-Stykkisholm	+.41	+.61	+.58	+.66	+.41	+.61	+.67	+.19	+.38	+.43	+.42	+.27	+.47
Jacobshavn-Stykkisholm	+.41	+.57	+.55	+.50	+.22	+.34	+.34	+.30	+.54	+.42	+.57	+.47	+.44
Temperature difference:													
Tromso-West Greenland	+.18	+.42	+.49	+.48	+.21	+.60	+.16	+.45	+.54	+.55	+.47	+.38	+.41

NOTE.—Explanation of the preceding table: The first correlation coefficient, +0.36, is the correlation coefficient of the air pressure difference Rome-Ponta Delgada in January with the change in pressure gradient Ponta Delgada-Iceland from January to February; that is, with the difference February mean−January mean of this pressure gradient.

In agreement with the theoretical requirements it appeared that after a supernormal pressure difference Rome-Ponta Delgada there follows pressure rise at Ponta Delgada and therefore increase in the pressure gradient between Ponta Delgada and Iceland, and that after a greater than normal pressure difference Haparanda-Stykkisholm or Jacobshavn-Stykkisholm there follows pressure rise at Stykkisholm and therefore decrease in pressure gradient from Ponta Delgada to Stykkisholm. Knowledge that the relation to the meridional pressure gradient is effected indirectly at first is gained from the fact that the correlations of the two northern zonal pressure differences with the air pressure change at Stykkisholm is still greater than the correlations with the change in pressure gradient. The same is also the case relative to the correlation of the temperature difference Tromso-West Greenland, which is likewise in harmony with theoretical considerations. All of these correlations show the same sign in all months of the year. The order of the correlation coefficient is not the same, however, in all months of the year since the period of action is not always the same in the course of the year. The correlations are of greatest importance in the months of February, March, and April and later in October. Detailed investigation shows that in these months the relations are linear, stable, and real. From the relations to the four zonal pressure differences, the relation to the temperature difference Tromso-West Greenland, and the correlation with the preceding meridional temperature gradient there result relation equations with total correlation coefficients of 0.80 to 0.81. The value of R^2 is therefore 0.64 to 0.67. The change in pressure gradient is determined thus at some two-thirds of the zonal pressure differences, the temperature difference between the eastern and the western parts of the circulation belt, and the meridional temperature gradient—a new proof of the determinant significance of previous weather history.

For those months that gave rather small correlation values with the use of monthly means the extent of the period of action must first be obtained. Such investigations are now under way. There is in progress, too, a study as to whether the length of the period of action is dependent on sunspots or other influences.

Although these investigations relative to conformity to law in the oscillations of the North Atlantic air circulation have for the time being no direct value in long-range forecasting, since the weather depends not alone on the air pressure gradient from the Azores to Iceland, they mark a point of progress on the long, difficult road to long-range weather forecasting in that there are involved here the first relation equations that were obtained in strict adherence to theoretical considerations and calculations and which in the demonstrated stability and reality of each individual relation give a close connection between a meteorological value and a preceding complex of phenomena.

AN INLAND EMPIRE LONG-PERIOD RAINFALL RIDDLE [1]

By E. M. KEYSER

[Weather Bureau Office, Spokane, Wash.]

Spokane County in northeastern Washington and Bonner County in northern Idaho, adjoining on the State line, although meteorologically similar, hold quite contradictory long-period rainfall evidence. So positive and so opposite are the testimonies from these two sources, not over 75 miles apart, that we have a genuine long-time precipitation riddle. Both bodies of evidence indicate that the Inland Empire is unusually dry. However, one set of facts indicates the passage of a comparatively wet period and the recent arrival of a much drier period, while the other set indicates the approach of the end of a very dry period and possibly the time for a return to another wet period.

Inasmuch as future widespread industrial activities not only in the Inland Empire, but perhaps in other parts of the Pacific Northwest, would be most adversely affected by any further dessication, a knowledge of the underlying causes is most desirable. A great opportunity is open to meteorology and the sister sciences to analyze the present evidence and discover new facts and determine, if practicable, what Jupiter Pluvius may have in store for the "Spokane country" during the coming decades.

In this precipitation dilemma, the Spokane County testimony has been attractively brought to the attention of meteorologists in an article in the MONTHLY WEATHER REVIEW entitled, "Evidence of Prolonged Droughts on the Columbia Plateau Prior to White Settlement," by Dr. O. W. Freeman of Cheney, Wash. Vol. 57: 250-51.

His observations may be summarized as follows: Recent subnormal rainfall, particularly in 1926, has been attended in some of the lava bed lakes southwest of Spokane, by unusually low lake levels. The receding water has exposed to view stumps of pine trees originating at some unknown date in Silver Lake and Granite Lake. These stumps, now just above the low-water's edge, represent, as determined by a count of their rings, trees of as much as 100 years' growth. The argument is that during some prolonged drought prior to the coming of the white man the water levels of these lakes remained sufficiently low for a century or more for these trees to attain their growth, for such trees do not grow while standing in water. Then came the comparatively wet period from which we have in the last few years just emerged and raised the level of the water, submerging the lower portions of the trees. This high water, fluctuating in its surface level, not only killed the trees, but finally rotted them at the water line and the trees fell, leaving the present stumps. A well authenticated photograph taken some 20 years ago shows these trees were still standing in 1908. Now, the stumps remain in mute testimony of a dry cycle of at least a century. For such trees to mature would require a level considerably lower than the 1926 level. Well may we wonder when this part of the country was dry enough to allow such uninterrupted growth at such low water and whether the country is again going into still scantier rainfall.

In confirmation of the silent testimony of these stumps, the author calls attention to low water levels in eastern Oregon at Goose Lake, Malheur Lake, and Harney Lake in 1926.

In one dried up lake bed well defined wagon ruts were found, supposedly made by some pioneer in the forties since this floor of the lake has not been out of water since the region was permanently settled. If the presence of the stumps in these lakes is explainable from only a meteorological angle then the shrubs and saplings now invading the exposed bottoms may possibly be permitted to reach the ripe age of 100 years during a new dry cycle just now dawning and by the year 2050 A. D. be submerged by the next wet cycle and fare the fate of their present mute predecessors.

However, let us look to the other horn of our dilemma where indications point not to the immediate passing of a wet period but to the passing of a 40-year extremely dry cycle. This evidence from the Priest River drainage basin in Bonner County is of an undoubted meteorological character. It was called to the attention of students of forestry by Robert Marshall in an article in the Journal of Forestry.[2] Briefly presented it is this:

An exceptionally careful study of the ring growths of white pine trees near the Priest River Experiment Station with which Mr. Marshall for a while was connected convinced him that there have been in this section alternate wet and dry cycles of comparatively short lengths. For this study he selected five sets of different aged trees, viz, 70, 140, 180, 230, and 280 years old, using from 8 to 15 trees in each set for his averages. Trees were from well-drained soil and from locations affected as little as possible by other than meteorological conditions. His conclusions, graphically shown are that since the year 1675 when his first set of trees started there have been three distinct wet period and three equally distinct dry periods, varying in length from 20 to 39 years. His dry cycles were: 1746-1785, 1826-1845, 1886-1925; his wet cycles alternated from 1706-1745, 1786-1825, and 1846-1885. This study as stated took into consideration the fact that such items as temperature, sunlight, location, winds, fire, age, all exert an influence on growth of wood tissue. To confirm his selection of these cycles, the author used at least two independent checks.

Realizing that more trees start to grow during dry periods than in wet ones, he inventoried trees of three contiguous national northern Idaho forests with reference to the dates of their origin. He thus discovered that by far the largest percentage of trees, regardless of age considered, originated in his determined dry periods. The other check was that of history including the Spokane 45-year precipitation record since 1881. In the years of 1805 and 1806, Lewis and Clarke made notes on weather conditions to the effect that while in northern Idaho and western Montana during June, July, and August, there were 32 rainy days whereas we are now carrying a normal of 20; and that "it rained, as usual"; or that the Indians were setting fire to trees to "stop the rain." This occurred near the middle of the 1786-1825 wet period. Also it is noted that Washington Irving, historian, in relating the experiences of the Oregon pioneers, he quotes them as saying in 1834 that "all the plains and valleys were in one vast conflagration" and that the "mountains were enveloped in smoke" and that they had had difficulty in keeping together because of the

[1] Presented at the meeting of the American Meteorological Soc. at Eugene, Oreg., June 20, 1930.

[2] April, 1927.

smoke. We see that the year 1834 falls in the dry period of 1826–1845.

Not only does the Marshall graph of tree ring growth by pentads since 1675, by preponderance of evidence, support his determination of these brief, alternately wet and dry cycles, but it shows in a rather conspicuous way the degree of wetness or dryness. For instance, probably due to excessive rains or snows, comparatively heavy growth is shown for the periods 1706–1745 and 1786–1825. Very light growths were indicated for 1760–1770. But the most striking truth brought out in this tree-ring investigation is that in all ages of trees there has been a radical decline of tissue growth since 1885, except that this decline was materially halted in all ages of trees considered from about 1896 to 1902. This spurt of growth during the final decline is accurately reflected in the Spokane weather records for the years 1896 to 1902, which, despite a rather dry 1898, show average precipitation of 18.75, more than 2.00 inches above the present Spokane normal. Notwithstanding those recent seven wet years, Mr. Marshall concludes that the 40 years from 1885 to 1925, where his investigation ended, were by far drier than any similar period in the last 280 years.

Thus we find two neighboring counties, whose settings are meteorologically homogeneous, presenting diametrically opposite precipitation cycle evidence. The Granite Lake stumps point to a dry past of unknown origin terminating within the last two or three decades. The Priest River trees show no dry period in the last 280 years approaching in severity that of the last five decades. How could Granite and Silver Lakes trees grow at such low water levels while the Priest River Basin was enjoying heavy precipitation?

The proper solution of this enigma would be of much scientific interest as well as economic importance. Such a solution should without doubt consider the following.

Marshall's careful determinations of alternate wet and dry cycles by ring growth in more than 50 white pine trees in Bonner County are closely paralleled in similar determinations of ring growths in 23 Douglas firs 25 miles northeast of Portland, Oreg., whose age was approximately 210 years. From a table[3] by A. E. Douglas measurements indicate corresponding heavy growths in Marshall's wet periods and corresponding light growths in his dry periods. Between the white pine site in Bonner County and Granite Lake in Spokane County are numerous fresh water lakes now at unprecedented low water on whose banks ancient stumps are not revealed. This absence of old stumps on lakes to the north of Spokane needs adequate explanation. Is it not possible that the lava bed lakes now showing stumps have at some time in the past had a common subterranean outlet active at the time of the production of the old trees? Then also is it not possible that by some slight geological movement this outlet could have been in recent years blocked? Thus may these lakes have been filled and the trees killed. The present low water need not be accounted for by a reopening of the subterranean outlet, but by the general drought of the last few decades.

A complete solution of this riddle should take also into consideration a chemical analysis of the waters, and a study of the biology and geology of all the lava bed lakes. Also a correlation of the rings of the old stumps with those higher up on the slopes and with those of the Marshall white pines and the Douglas Oregon firs, while probably not likely to be convincing, would be of intense interest.

[3] See Climatic Cycles and Tree-Growth, by A. E. Douglas, Carnegie publication No. 289.

TULARE LAKE[1]—A CONTRIBUTION TO LONG-TIME WEATHER HISTORY

By C. E. GRUNSKY, Eng. D.

[1930]

In making a study of the water resources of the San Joaquin Valley, Calif., for the State engineer department, during the years 1881 to 1888, certain interesting facts were developed by the writer which should be more widely known, because they throw some light upon the weather conditions in Central California, or, more particularly, in the southerly San Joaquin Valley watershed, preceding any historical records. The facts to which attention will be directed relate to Tulare Lake which, during the last 30 years, has been repeatedly dry. In consequence of this condition the assumption is now generally made that the lake is a thing of the past; that its dry bed for the most part at least will remain dry hereafter.

That this assumption is premature and that the lake may at some unknown time in the future again attain a high stage will appear from a review of the history of the lake which had best be given by reference to the facts as they came to my attention. In 1881 and the years following I had occasion to make a number of visits to the lake region after having informed myself from maps and reports of the topography and behavior of streams in the watershed and in the immediate vicinity of the lake. It will be recalled in this connection that Kings River which drains a large watershed on the western slope of the Sierra Nevada Mountains, enters the San Joaquin Valley at a point easterly from Fresno. The course of the river across the valley, or, rather, across the broad east side plain of the valley, is southwesterly. At a point about midway of its course across this plain the delta formation of the river begins. The river, before its course was modified by human agency, sent some of its flood flow into numerous overflow or high water channels of which those toward the south discharged into the depression in which Tulare Lake lies and those toward the north were tributary to San Joaquin River. At low water stages, during the period when Tulare Lake is not overflowing, the discharge of Kings River is into the lake.

The delta of Kings River has been built up by the sand and silt which the river has brought into the valley, forming a broad flat-topped delta ridge which extends across the trough or lowest part of the San Joaquin Valley now appearing in the topography as a flat dam or barrier miles in width. Upstream or south from this barrier the original valley trough is at materially lower elevation than the lowest point on the crest of the ridge. A saucerlike depression has thus been formed upstream from the delta of Kings River. The water trapped in this depression forms Tulare Lake.

Probably 100 square miles of the lake bed are at about elevation 179 feet above mean sea level. The lake was at a very high stage in 1853 after several seasons with more than ordinary rainfall. Thereupon there was a

[1] Presented before American Meteorological Soc., Eugene, Oreg., June, 1930.

FIGURE 1.—Willow stumps in Tulare Lake bed, 1882. Grunsky

gradual recession of the lake with a drop in its water surface to about elevation 200 feet in the fall of 1861. The highest lake stage followed immediately. It was produced by the very wet winter of 1861–62 and the same stage was attained a second time in 1868, both at about elevation 216 feet, at which stage the maximum depth of water in the lake was about 37 feet. The area of the lake at this high stage was about 750 to 800 square miles. At elevation about 206 feet, water from the lake under ordinary conditions could flow northerly in a well defined channel toward the Fresno Swamp and thence into the San Joaquin River and at about elevation 210 feet the water of the lake over-topped the lowest point on the Kings River delta ridge. At the lake's highest stage about 6 feet of water was flowing in a broad expanse northerly over this ridge.

Information, received by me (1881 and 1882) from some of the farmers in the vicinity of Hanford—in the Mussel Slough country—was to the effect that the lake had reached an unusually low stage and that its recession had laid bare an area near the mouth of Mussel Slough, at the lake margin, covered with stumps of trees. This information prompted an investigation, with the result that these stumps were found and sketches were made (1882). The ground on which they stood is at about elevation 197, or about 22 feet below the highest known stage of the lake. At this point there was clear evidence of the location of an old channel entering the lake area from a northeasterly direction. Undoubtedly this was at one time one of the channels of Mussel Slough, most likely its principal channel, during a protracted period in which the lake was at or even below its then low stage.

There were about 100 stumps to be seen. These were probably all willow tree stumps. Their tops were ragged as though the trees had been broken off. They stood in part at the south side of the old slough channel, upon ground the surface of which ranged from the water's edge to perhaps 1 foot above the water surface. Some stumps were, in fact, on ground still covered with water. I tied my horse to one of the stumps and took time for a sketch which is the basis of the illustration which accompanies this paper.

Some of these stumps had a diameter of about 4 feet. Their dimensions and their position indicated that they were the remnants of a grove of willows which had reached mature growth along the bank of the water course and along the margin of the lake. It may safely be assumed that low lake stages with conditions favorable to the growth of these willows must have been continuous for a period of some 40 or 50 years or perhaps much longer. There was here then positive evidence that, at some time in the past before the arrival of the white man on the scene, the lake had been at or below the elevation of about 195 feet above sea level for a long period of time. The elevation here noted was ascertained by a survey made by me for this purpose in the fall of the following year (1883).

Furthermore, after the lake rose to a stage high enough to drown this willow growth, it remained at or above this stage for 50 or 100 or more years keeping the stumps, after the trees had died and had been broken off, submerged until their discovery about 50 years ago. The long period of persistently light or moderate rainfall favoring the growth of the willows was followed by a long period in which the frequency of fairly wet winters kept the lake at fairly high stages, culminating as noted, with the very high waters of 1853, 1862, and 1868.

With the information relating to so much of the history of the lake as disclosed by the willow stumps as a background, I interviewed some of the oldest residents of the lake region—among others Mr. Daniel Rhoads, of Lemoore. He informed me that there was an old Indian tradition to the effect that many years ago the lake had dried up. The Indians could cross from the east to the west side of the valley between two small ponds of water.

It was from Mr. Rhoads and others that information was also obtained relating to the stage of the lake prior to the very wet winter 1861–62 and also relating to the high water stage following this winter and a second very high stage in the year 1868.

It developed from this inquiry that enough water was discharged in the single season 1861–62 by Kern River, Tule River, Kaweah River, Kings River, and a number of lesser streams into the lake basin to raise the lake's water surface 16 feet. The lake, by reason of this inflow of storm water, was increased in surface area from about 350 square miles in 1861 to nearly 800 square miles in 1862. Moreover as the lake approached its highest stage some of its water went out through the outlet channel already referred to and over the top of the Kings River delta ridge northerly into the Fresno Swamp and thence into San Joaquin River. No determination of the volume of water that thus flowed northerly out of the lake basin has been attempted.

It is, however, readily estimated from the lake stages before and after the winter of 1861–62 that there must have been an inflow of water into the lake region in a single season 1861–62 of more than 5,000,000 acre-feet of water. While the water surface elevation of the lake as determined by survey in 1883 was called its lowest known stage by everyone familiar with the lake, the weather conditions since then have failed to maintain the lake even at that level. With many minor fluctuations, the lake has gradually dwindled in size. Its water surface became lower and in the fall of 1898 the lake bed was bare.

Learning of this fact I made a second survey early in 1899 to determine by spirit leveling just what the elevation of the bed of the lake is. It was found to be about 179 feet. Since that time water has reached the lake area practically every year, but not always in quantity to exceed the annual evaporation.

It is natural that the shrinking of the lake and present conditions in the lake region should be attributed by many to the diversion, for irrigation, of the water naturally in the streams which flow into the lake area. While this use must, in some measure, reduce the quantity of water delivered into the lake, its effect during seasons of large water production will be almost negligible.

When, in the light of the above facts, it is recalled that the highest lake stages were preceded by a very long period of low lake stages which must be taken to indicate a very long period with winter rainfall but little above or at, or below normal and no excessively wet winter at any time during this long period, we must conclude that the similar period, devoid of winters with excessive rain, which we are now experiencing and which commenced about 1890, will certainly some day be followed by occasional winters with rainfall comparable with that of 1861–62 or perhaps even with a succession of very wet winters. Moreover no information is available which would permit a reasonable conjecture as to the length of time that the water of the lake covered the area on which the willows grew. This again was a long period. It must have commenced

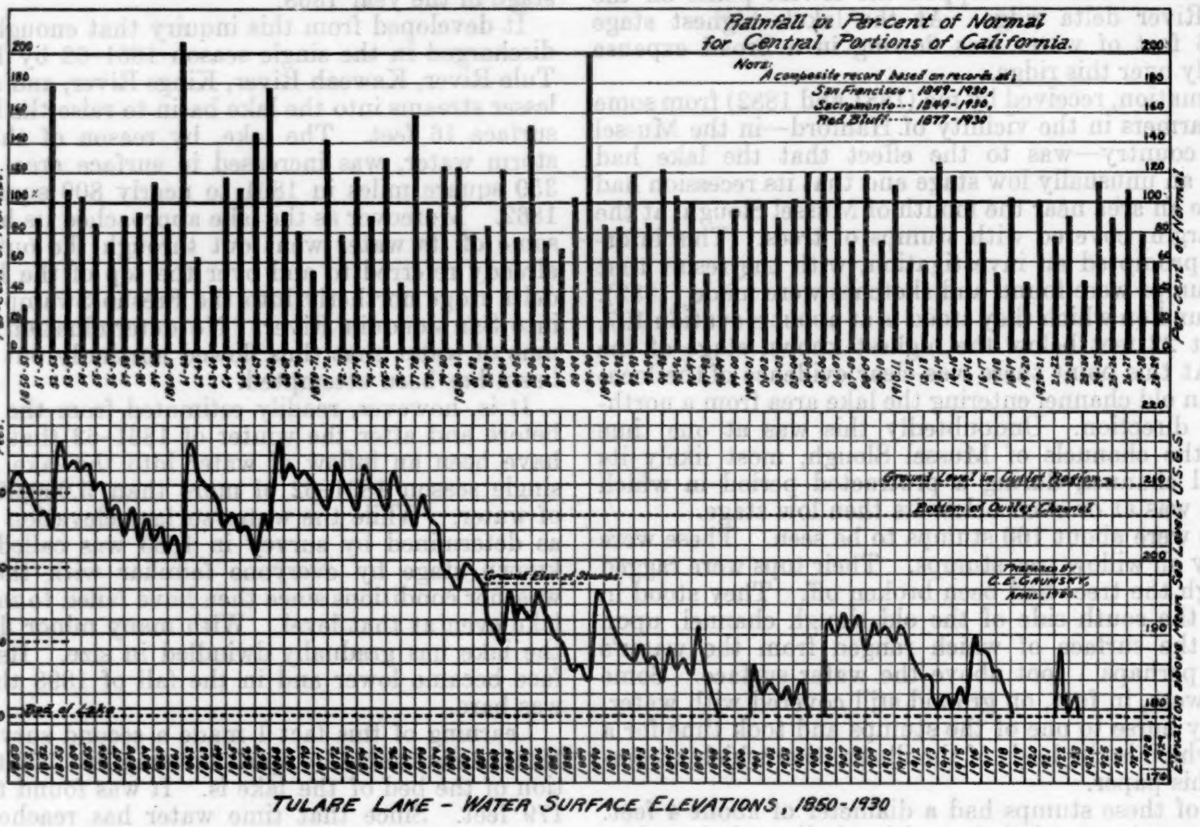
long before the first explorations of this region. Its commencement may have been in the eighteenth century or even earlier—probably not in the nineteenth for which contemporary or near contemporary records show unusually wet winters as follows: 1804–5, 1824–25, 1845–46, 1849–50, 1852–53, 1861–62, 1883–84, and 1889-90.

That there were in this nineteenth century also some very dry seasons is well known. Such for example was the winter of 1828–29 in which, as the mission records show, some 40,000 cattle died in the southern counties for lack of food and water; and the winter of 1863–64 with very little rainfall, disastrous to cattle and crops, intermediate between the two high stages of Tulare Lake above referred to. (See diagram showing the stage of Tulare Lake, 1849 to 1930, and seasonal rainfall in central portions of California.)

It appears from such evidence as the above that it would be improper to assume that, because California, considered in its entirety, has not had a very wet winter in recent years, the climate has changed and that never again will so much rain and snow fall as in the winter of 1861–62. On the contrary, the facts which have been cited should rather be taken to indicate that there may be many years in succession without excessive precipitation and that there may be other periods, perhaps centuries in duration, in which years or seasons with excessive or relatively high precipitation will be frequent.

In this connection it may be recalled that the city of Szegedin in Hungary, after 100 years of protection against overflow, had its levees overtopped in 1879 by the high waters of the River Theis. So too, the recent high waters in southwestern France indicated heavier rainfall in that region than had been experienced since 1770. At Vienna on the Danube the greatest flood of which there is record occurred in the year 1501 or more than 400 years ago. Twice near the end of the last century the Danube reached stages at Vienna that were exceptionally high, but at which the volume of water brought down by the stream at its peak was only about three-fourths of that during the greatest flood in 1501. Many other instances could be cited of the long time interval between extreme rainfall and runoff conditions, going to show that no material change in historic times in the amount of rainfall to be expected in any locality should be assumed.

Even such facts as the retreat of the Alaskan glaciers, the gradual disappearance of glaciers on the slope of Mount Shasta, and of the recent sudden melting away of the Palisades Glacier (1924) on the eastern slope of the Sierra Nevada, should not be taken as conclusive evidence of a change in climate, but should rather be attributed to a sequence of years with deficient snowfall and more than normal summer heat—factors which are conducive to the shrinkage of the ice fields and which may be followed by another sequence of years in which conditions are reversed.



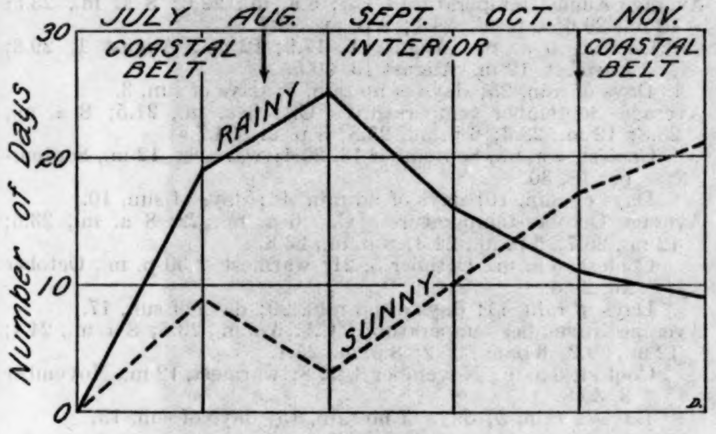
TULARE LAKE - WATER SURFACE ELEVATIONS, 1850-1930

CLIMATE OF LIBERIA [1]

By HAROLD J. COOLIDGE, Assistant Zoologist on the Expedition

[Harvard University, Cambridge, Mass.]

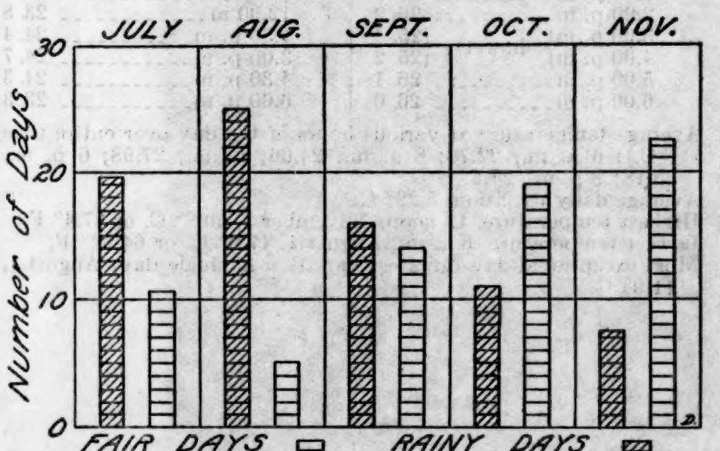
The rainy season was well under way in July and except for a let up of a week or 10 days in late July (a period known as the middle dries), it continued until some time in October. The dry season was well begun in November. The latter part of September and in October there were frequent thunder showers, usually in the late afternoon.



KEY TO DIAGRAMS

I. Curve to show days of rain during our visit, and curve to show days of sun during our visit

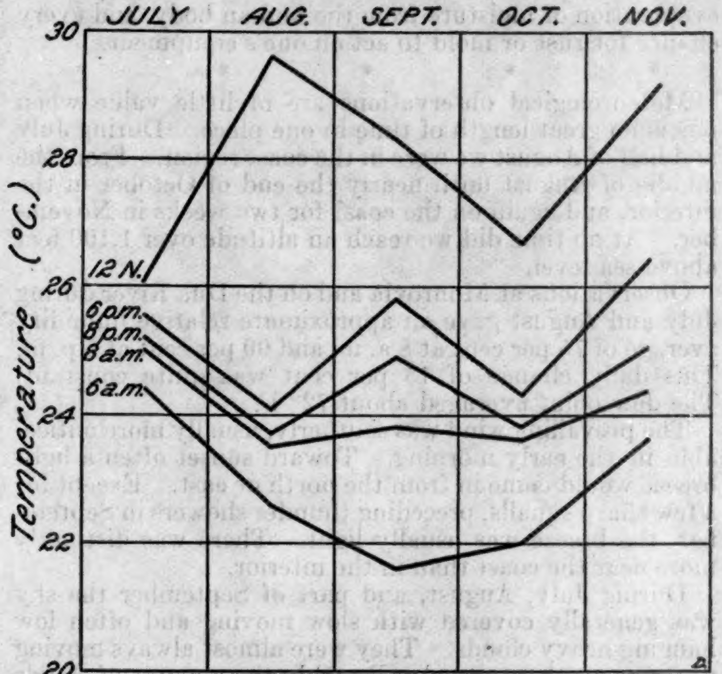
According to Sir Harry Johnston, September and October have the reputation of being the most unhealthy months and February the coolest and driest. On February 3, 1905, the shade temperature at Mount Barclay, 20 miles from Monrovia, registered 100° F. at 2.30 p. m. The average annual rainfall in the coast



II. Lines to show proportion of days of rain to days of no rain by months

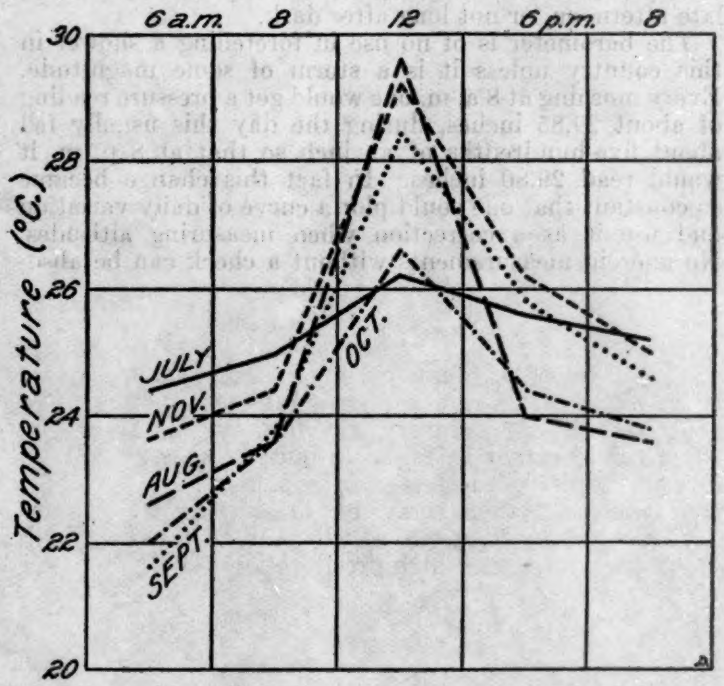
regions of western Liberia is about 153 inches. In 1905 the greatest precipitation in 24 hours at Mount Barclay was nearly 8¾ inches, while the amount by the month was 5 inches in January, ⅛ inches in February, 1⅛ inches in March, 5¼ inches in April, 19 inches in May, 33 inches in June, 22 inches in July, 29 inches in August, 17 inches in September, 8 inches in October, 6 inches in November, 5 inches in December. [2]

The distinct advantages of visiting Liberia in the rainy season are two. One, Liberia is usually shaded from the direct light of the sun by a blanket of clouds, even at noon. Two, the range of temperature in every



III. Curve to show comparative trend of temperature at specified hours in different months

24 hours is not great and the average day temperature is cooler than during the months of the dry season.



IV. Curve to show comparative monthly trend of temperature at specified hours of the day

On the other hand there are discomforts that go with traveling during the rains in a country where as yet many of the trails are stream beds. Most of the native bridges

[1] The Harvard African Expedition, lead by Dr. Richard Strong, visited Liberia from July 7 to Nov. 21, 1926.

[2] From Liberia, Vol. I, Sir Harry Johnston.

are carried away by the swollen streams. Many of the native houses have leaky roofs. Walking long distances or making collections in the bush is often disagreeable, to say nothing of trying to dry specimens of animal skins or plants. The most unpleasant thing of all is probably the extremely high relative humidity which reaches as much as 98 per cent. At such times there is very little evaporation of moisture from the human body, and every chance for rust or mold to act on one's equipment.

* * * * *

Meteorological observations are of little value when one is no great length of time in one place. During July and half of August we were in the coast region. From the middle of August until nearly the end of October in the interior, and again on the coast for two weeks in November. At no time did we reach an altitude over 1,100 feet above sea level.

Observations at Monrovia and on the Dua River during July and August gave an approximate relative humidity average of 75 per cent at 8 a. m. and 90 per cent at 8 p. m. This daily change of 15 per cent was quite constant. The dew point averaged about 72° F.

The prevailing wind was southerly, usually more noticeable in the early morning. Toward sunset often a light breeze would come in from the north or east. Except for a few sharp squalls, preceding thunder showers in September, the breeze was usually light. There was distinctly more near the coast than in the interior.

During July, August, and part of September the sky was generally covered with slow moving and often low hanging heavy clouds. They were almost always moving north or northwestward. Roughly the amount of clouds covering the sky would be about eight-tenths. This made the general character of every day gray or cloudy. The showers usually came in the afternoons. If it did rain in the morning, it was very apt to continue to do so all day. The heaviest rains were usually in the forenoon, late afternoon, or not long after dark.

The barometer is of no use in foretelling a shower in this country unless it is a storm of some magnitude. Every morning at 8 a. m. one would get a pressure reading of about 29.85 inches, during the day this usually fell about five-hundredths of an inch so that at 8 p. m. it would read 29.80 inches. In fact this change became so constant that one could plot a curve of daily variation and use it as a correction when measuring altitudes. No aneroid measurements without a check can be absolutely accurate. (The expedition used a Green-sling psychrometer for determining the temperatures and humidity; and a Watkins 3-circle barometer for the pressure.)

WEATHER SUMMARIES

(When a day is half in half it counts half for each)

Average July temperature (°C.): 6 a. m., 24.2; 8 a. m., 25; 12 m., 26.1; 6 p. m., 25.5; 8 p. m., 25.2.
Coolest 6 a. m., July 26, 22°; Warmest, 2 p. m., July 31, 28.5°.
Days of rain, 15½; days of no rain, 9½; days of sun, 8.

Average August temperature (°C.): 6 a. m., 22.6; 8 a. m., 23.5; 12 m., 29.6; 6 p. m., 24.1; 8 p. m., 23.7.
Coolest, 6 a. m., August 1, 17.9; 12 m., August 1, 29.8; warmest, 12 m., August 13, 30.5.
Days of rain, 25; days of no rain, 5; days of sun, 3.

Average September temperature (°C.): 6 a. m., 21.5; 8 a. m., 23.8; 12 m., 28.3; 6 p. m., 25.8; 8 p. m., 24.7.
Coolest, 6 a. m., September 13, 20.4; warmest, 12 m., September 18, 30.
Days of rain, 16; days of no rain, 14; days of sun, 10.

Average October temperature (°C.): 6 a. m., 22; 8 a. m., 23.6; 12 m., 26.7; 6 p. m., 24.3; 8 p. m., 23.8.
Coolest, 6 a. m., October 5, 21; warmest, 2.30 p. m., October 20, 29.6.
Days of rain, 11; days of no rain, 20; days of sun, 17.

Average November temperature (°C.): 6 a. m., 23.5; 8 a. m., 24.4; 12 m., 29.2; 6 p. m., 26.2; 8 p. m., 25.1.
Coolest, 6 a. m., November 3, 22.8; warmest, 12 m., November 3, 30.8.
Days of rain, 5; days of no rain, 15; days of sun, 13.

COMPARISON

Range of temperature on an average day in Belgian Congo at Stanleyville, January 13, 1927 (°C.):		Range of temperature on an average day with rain in Liberia at Kakatown, August 22, 1926 (°C.):	
7.30 a. m.	24.65	6.00 a. m.	22.4
8.30 a. m.	24.8	7.30 a. m.	22.8
9.30 a. m.	25.3	8.30 a. m.	23.3
11.00 a. m.	26.1	9.30 a. m.	23.5
1.00 p. m.	27.5	11.00 a. m.	23.4
2.00 p. m.	26.9	12.00 m.	23.8
3.00 p. m. (shower)	25.4	1.30 p. m.	24.4
4.00 p. m. (shower)	25.2	3.00 p. m.	24.7
5.00 p. m.	26.1	4.30 p. m.	24.3
6.00 p. m.	26.0	6.00 p. m.	23.3

Average temperature at various hours of the day over entire time (°C.): 6 a. m., 22.76; 8 a. m., 24.06; 12 m., 27.98; 6 p. m., 25.18; 8 p. m., 24.5.

Average daily variation, 5.22° C.

Highest temperature, 12 noon, November 3, 30.8° C. or 87.4° F.

Lowest temperature, 6 a. m., August 1, 17.9° C. or 64.22° F.

Most exceptional day (greatest variation in single day) August 1, 11.9° C.

WEATHER ABNORMALITIES IN THE UNITED STATES (8TH NOTE)—HIGH TEMPERATURE IN JULY, 1930

By ALFRED J. HENRY

The daily maximum temperature in Washington, D. C., in July, 1930, passed the 90° mark on 18 days and the 100° mark on 6 days, 4 of which were consecutive. The maximum of the month, 106° on the 20th, was also the absolute maximum during the period of observations that began in 1870. The 4-day period of maximum temperature of 100° or more is also a second high point in the last 60 years of observation. These extraordinary temperatures were not peculiar to the eastern seaboard but prevailed also over a very considerable part of the country from the eastern foothills of the Rocky Mountains to the eastern seaboard States of Maryland and Virginia and from North Dakota to northern Louisiana. Also in California and Arizona although high temperatures locally in these States are more or less common in the hot season, especially in the Great Valley of California and in the lower Colorado Valley in Arizona and California.

It might be inferred that unusual atmospheric conditions must have been experienced in order to cause such high temperatures; on the contrary the novice in reading the daily weather charts doubtless would be more or less puzzled to account for the high temperatures that prevailed over so great an area.

There are at least three great factors in the heating of the atmosphere, viz, (1) the amount of solar radiation; (2) the horizontal transfer of heat from place to place, and (3) the amount and character of terrestrial radiation.

Thanks to Abbot and his colleagues the amount of solar radiation received day by day is pretty well known but we can not, as yet, pass directly from measures of the daily output of the sun to the corresponding terrestrial temperatures. The second factor—the horizontal transfer of heat by the wind and by ocean currents—seems to be the chief agency by which daily changes in temperature are brought about. Little is known, quantitatively, of the amount of cooling that may be due to radiation from both the earth and its atmosphere.

The solar constant values as cabled from Montezuma, Chili, to the Astrophysical Observatory of the Smithsonian Institution and published on the Weather Bureau daily weather chart for July were higher than the average, but as above indicated no one has been able to satisfactorily correlate solar constant measures and terrestrial temperatures; it may be said, however, that studies of a sequence of daily constant measures and temperatures at Washington, D. C., by Dr. C. G. Abbot show some correlation between high solar constant values and high temperature at Washington.

The second factor, viz, the horizontal transfer of heat from one point to another, finds its fullest application in the cold season when the air currents bring tropical air from the south and conversely when northerly currents bring polar air into lower latitudes. It is therefore through the agency of cyclones and anticyclones that periods of pronounced heat and cold are brought about. In summer, however, while cyclones are associated with higher temperatures around their eastern and southern fronts, it may be questioned whether that increase in temperature is directly due to the presence of the cyclone. An alternative view is that due to the cumulative effect of solar radiation from clear skies in areas remote from the sea, minus the loss of heat by nocturnal radiation, a heat balance is accumulated that is favorable to high maxima; for example, a cloud blanket at night may so diminish nocturnal radiation that the morning temperature may be several degrees higher than it was on the previous morning and as a result the maximum is higher by that amount than on the previous day, with practically the same amount of solar radiation.

An examination of the days during July, 1930, when maximum temperatures as reported telegraphically from the 200 and more weather stations in the United States and Canada reached and passed 100° clearly shows a high degree of correlation between the current high temperatures and the geographic center of the barometric depression.

It is not known for a certainty whether the high temperature is the cause of the low pressure or vice versa.

One of the relations between the temperature and the immediate proximity of a cyclonic wind system about which there is no shadow of doubt is that when the sequence is cyclone-anticyclone-cyclone the higher temperature of the cyclone gives way to the lower temperature of the anticyclone; but when the sequence is cyclone-cyclone-cyclone without the intervention of an anticyclone the result is high temperature for the season, the degree of warmth being conditioned upon the time that such a sequence prevails.

This in short is the explanation of the visible mechanism whereby exceptionally high temperatures were prevalent in various parts of the United States in July 1930. The heated spell as a whole may be referred to the passage of at least eight ill-defined low pressure areas along the Canadian border or a little north of it.

NOTE ADDED AUGUST 18, 1930

The foregoing was prepared for the July issue of this REVIEW. While the temperature on the 1st of August was slightly below the normal a second heated spell, or perhaps a continuation of the first set in on August 2 culminating in a maximum at Washington, D. C., of 102° on the 4th and 5th and again on the 9th. There were 5 out of the first 10 days of August with maximum temperatures of 100 or over and 7 days with maxima of 90° or more. The heated spell came to an end on August 10 when the maximum temperature was but 89° and the mean temperature dropped below normal on the 11th and has remained below at the date of this writing (August 18).—*A. J. H.*

The foregoing presents merely the facts of pressure distribution in the United States and Canada during the heated term. Owing to circumstances into which I need not enter at this time the complete data of monthly mean pressure for the world-wide network of meteorological stations in the Northern Hemisphere for several months prior to July of this year are not available and will not appear in printed form until, say 1938 or eight years hence, basing this statement on the fact that the most recent world-wide data are for the year 1922. Neither should it be assumed that if the more recent data were available the answer to the why and the wherefore of the heated term would be immediately forthcoming.

A true scientist does not demean himself or the science he represents by admitting defeat in the solution of some of the problems he encounters. Meterologists have known

and studied cyclones and anticyclones for upward of 60 years. Many things are known as to their movement and the relation of that movement to the weather a few days in advance; but just how and why they come into being and follow this course or that course or quickly cease to exist is one of the unsolved problems of the meteorologist. When these pressure formations fail of development in the usual number, or when they lack in the essential characteristics of form, continuity, and speed of travel high temperature and sometimes, but not always, widespread drought occurs; in other words "stagnation" or the breaking down of the secondary circulation is the fundamental fact that furnishes the keynote to the abnormality. Why it should stagnate or break down we do not know. Reeder (this REVIEW 47:711–715) associates droughts and hot weather with the movement of cirrus clouds from the east, or in other words the currents in the cirrus level are reversed for the time being.

NOTES, ABSTRACTS, AND REVIEWS

Beitrag zur Langfrist-Wettervorhersage. By F. B. Groissmayr. Ann. Hydrogr. Berlin, 1928, pp. 287–293, 310–317[1]—The main interest of this pair of papers is the influence of Charleston rainfall on world weather, and I have prepared a note which follows in criticism. The following are some of the coefficients which Professor Groissmayr gets with Charleston rainfall: +0.64 with Charleston rain next year, +0.61 with the Nile two years later; −0.66 with Azores-Iceland pressure December to February two and one-half years later, in each case based on about 50 years of data. He also connects the autumn temperature of the Eastern United States with Argentine pressure in May preceding.

Note on Charleston rainfall and its relation to world weather.—In view of the surprisingly large coefficients obtained by Professor Groissmayr with a single rain gage at Charleston it seemed advisable to try whether the results would be equally shown by the rainfall indicated by the rain gages of the neighborhood. From the Summaries of Climatological Data by Sections [2] I selected a number of such stations and correlated their rainfall with the Nile two years later as follows: Hatteras 0.42, Pinopolis 0.24, Savannah 0.36, Wilmington 0.40; further, the mean of the seven stations—Jacksonville, Savannah, Augusta, Southport, Wilmington, Charlotte, and Pinopolis gave the coefficient 0.42 with 50 years of data. It may be concluded, therefore, that the relationship 0.60 with Charleston is fictitiously big.

Another test may be applied by extending the data still further back and a graphical comparison of the period 1834–1870 does not show a particularly close relationship.

It is also of interest to correlate with the Nile at intervals other than that of two years chosen by Professor Groissmayr. With Carolina rainfall and the Nile of the same year the coefficient is 0.20, with the Nile one year later 0.34, two years later 0.42, three years later 0.42, and four years later 0.28, so that there is a good deal of persistence probably due to slow changes common to both factors.

The above tests were made at the suggestion of Sir Gilbert Walker.

E. W. Bliss.

Maximum precipitation in short periods of time,[3] *by Charles D. Reed (Author's Abstract)*.—Records of the greatest precipitation in short periods of time are obtained by the United States Weather Bureau with automatic recording rain gages for the purpose of assisting architects in planning the drainage of flat roofs and engineers in designing sewers and other drainage.

The greatest rainfall in five minutes known to the Weather Bureau, in Iowa, is 0.80 inch at Dubuque. Dubuque also holds the record for the greatest amount in 30 minutes and 2 hours, while Sioux City holds the record for 10 minutes, 15 minutes, and 1 hour. Records for seven stations are available. The most frequent intensity at Des Moines for a 5-minute period is between 0.30 and 0.40 inch. There are 14 years with such maxima out of 33. As the intensity of rainfall decreases the frequency increases.

Meteorological Observations of the First Shackleton (Nimrod) Expedition, by Dr. Edward Kidson.—The first Shackleton Expedition, 1907–1909, established its base at Cape Royds on the west side of Ross Island. The geographic coordinates of the position are approximately latitude 77° 34′ S., longitude 166° 9′ E. This position will be recognized as the gateway used by the British and also by Amundsen through which access to the South Pole was sought. For one reason or another the meteorological observations made by this expedition were not promptly printed. On the initiative of the Australian National Research Council, the Commonwealth Meteorologist, and others, steps were taken to print the observations; accordingly, a small committee was formed, which in conjunction with Doctor Kidson prepared the volume under review.

Antarctica continues to be the goal of geographic exploration, notwithstanding the large amount of information thereon that has been accumulated since the beginning of the twentieth century.

The return of the American expedition of Admiral Byrd, as this note is being written, lends additional interest to the subject. The Ross Sea area in which the meteorological observations included in the work under review were made, is best known by the very comprehensive treatment of its meteorology by Dr. George C. Simpson, the meteorologist of the last Scott Expedition and now Director of the British Meteorological Service.[4]

In closing, I can do no better than to quote Doctor Kidson's remarks on page 120 of the work.[5]

General.—There is no portion of the earth comparable with the Antarctic in size of which our knowledge of the meteorolgy is so inadequate. Yet the interest attached to its weather processes is in many ways unique. Not only is it at one of the poles of the earth, but it is at the pole of that hemisphere in which meteorological conditions are the simpler and which offers, perhaps, the best field for the study of the general circulation. It is obvious that we can get no complete picture of world meteorology so long as such a gap remains, and the conclusion is rapidly being forced upon meteorologists in all quarters of the globe that their local weather is a function of world conditions. From the few and scattered records available it is already clear that the differences between seasons are accentuated in the Antarctic. Consequently, if a long series of records from a few well-distributed stations were available much might be learned regarding the nature and causes of seasonal variations in the world generally. It is very much to be hoped that the scientific problems of the region will soon again be attacked by properly organized bodies with resources adequate for the purpose. And when this is done, one of the most important aims should be the establishment of permanent meteorolgical stations.

[1] Reprinted from Meteorological Magazine, London, April, 1930.
[2] Washington. Bulletin W., 2d edition, 1926.
[3] Read before Iowa Academy of Science, May 2, 1930.

[4] British Antarctic Expedition, 1910-1913. Meteorology, vol. 1, discussion by G. C. Simpson, D. Sc. F. R. S., Calcutta, 1919.
[5] British Antarctic Expedition, 1907-1909. Reports on the scientific investigations Meteorology, by Edward Kidson, D. Sc., Melbourne, 1930, p. 120.

The meteorology of the Antarctic, although some of the disturbing factors to be found elsewhere are wanting, is sure to be highly complicated and difficult to elucidate. I can see no grounds for believing, as many meteorologists and geographers appear to do, that a solution of world problems in meteorology would follow quickly from research in the Antarctic. It is unscientific, for instance, to promise that seasonal forecasting would be greatly simplified. It is thoroughly unsound, also, at the present state of our knowledge, to ascribe seasonal changes to the movements of Antarctic ice. An adequate account of the ice conditions in the region would be most difficult to procure. Furthermore, seasonal changes are of a world-wide nature, and the ice conditions are much more likely to be a result of them than an important factor in their cause. It is usual to call an area where seasonal variations are very marked a "center of action." The term is a bad one, since it should imply that the region is one where original causes are especially active. What it really does imply is that effects are especially large or for other reasons easily measured there. The region may play a very passive part in the production of the conditions which it so clearly records. One would expect this to be the case with the Antarctic. When, however, we come to deal with long-period climatic changes, it is obvious that a study of the great polar caps is of the utmost importance, since they have so great an influence in deciding the use to which the solar radiation which reaches the earth is put.

Copies of the publication are available on application to the Secretary of the Commonwealth Council for Scientific and Industrial Research, 314 Albert Street, East Melbourne; or the Official Secretary, Australia House, Strand, London, at the price of 8 shillings.—*A. J. H.*

Sea thermograph installed on "S. S. Munargo," New York to South America.—Most interesting surface-temperature profiles of the Gulf Stream, Antilles Current, North Equatorial Current, and South Equatorial Current are in prospect from the Negretti and Zambra sea water thermograph recently purchased by the Munson Line and installed by the United States Weather Bureau on the steamship *Munargo*. The *Munargo* sailed from New York June 14 for ports on the east coast of South America. After possibly a second trip, the *Munargo* will resume its regular route to Nassau, Habana, and Miami.

The cooperation of the Munson Line in the general project of obtaining temperature records in the western Atlantic [6] is largely due to the interest of Mr. J. A. Erickson, Assistant Manager, Ownership Operations. The installation was completed by Mr. Benjamin Parry, United States Weather Bureau, with the assistance of Chief Engineer Buckingham and his assistant Mr. Olson.

Records of sea temperature are being obtained also on the Canadian National steamships *Lady Drake* and *Lady Hawkins*, with thermographs installed originally on the steamships *Canadian Forester* and *Canadian Fisher*, in 1927. These ships run from Halifax to Bermuda, St. Kitts, and various other places in the West Indies, finally reaching Demerara and returning to Halifax by the same route. The temperatures of the Gulf Stream, the Antilles Current, and the Equatorial Current are thus obtained. Dr. A. G. Huntsman, Biological Board of Canada, is the responsible scientist.—*C. F. Brooks.*

Broadcasting cosmic data.—Beginning August 1, 1930, the broadcasting of cosmic data by Navy radio station NNA, Washington, began; the message being added to the usual weather report message transmitted to the French radio station FYL, Lafayette, at the time 19:00 zone plus 5 (4 p. m. Eastern Standard Time) frequency 16,060 kilocycles.

The letters URSI is the distinguishing sign at the beginning of the cosmic message. URSI are the ititials of the Union Radio Scientifique Internationale (International Scientific Radio Union). Each class of data is coded separately and preceded by an identifying word—SOL for solar constant, MAG for terrestrial magnetism, SUN for sun spots, AURO for auroras. The data are expressed in a number code in groups of five, similar to that used in the transmission of meteorological data. Plain English will be used when extraordinary phenom ena demand it. The message is signed SCIENSERVEC the cable address of Science Service. Further details may be had on application to Science Service, Twenty-first and B Streets, Washington, D. C.—*A. J. H.*

Ice in the region of the Grand Banks, 1929.—The editor is in receipt of the annual report on International Ice Patrol in the North Atlantic.[7]

This bulletin contains a detailed report of the two Coast Guard vessels which alternate in 15-day shifts in the patrol. The outstanding feature of the 1929 season was its length and the very great amount of ice that prevailed. During the last few days of July the patrol had the very unusual experience of witnessing the melting of the southernmost bergs under visual observation due to the midsummer air and water temperatures and the apparent mixture of the surrounding northern waters with the Gulf Stream drift.

Father José Alqué, S. J. (1856-1930).—Born at Barcelona on December 28, 1856, José Algué began his studies at the Colegio de San Ignacio and early came under the influence of the Rev. Don José Faura, brother of the founder and first director of the Observatory of Manila in the Philippine Islands. His interest took a scientific turn, including mathematics, physics, and chemistry, and in 1889 he was selected by the superiors of the Compañia de Jesús to collaborate in the work of the observatory. In 1891 he visited the United States to study astronomy and in 1893 he took an active part, on behalf of Spain and the Philippines, at the International Meteorological Congress which met at Chicago. After this Congress he returned to Spain, and thence proceeded to Manila as assistant director of the observatory under Father F. Faura.

The year 1894 was remarkable for an extraordinary number of typhoons, and Father Algué immediately commenced the study which became his chief work. His first essay appeared in 1895, followed in 1897 by "Baguios o ciclones filipinos" and "El Barociclonómetro." The same year, on the death of Father Faura, he became director of the observatory. In 1904 followed his famous monograph "Cyclones of the Far East," indispensable for all subsequent studies of the phenomena of tropical cyclones. This work was written in English but has been translated into several other languages. Other meteorological work was not neglected, however; as early as 1898 he published a paper on "The clouds of the Philippine Archipelago." The network of stations and the meteorological service of the Philippines was continually expanded, including the erection in 1907 of the high-level observatory of Mirador, at a height of 1,512 meters, and Father Algué was a regular attendant at the International Meteorological Conferences. In 1906 he was elected an honorary member of the Royal Meteorological Society, and he has made three contributions to the pages of the Quarterly Journal. In 1924 he again visited Europe to organize the Philippine exhibit at the Vatican missionary exhibition of 1925, and then ill health made it impossible for him to return to Manila. He died at Roquetas on May 27, 1930.[8]

[6] Charles F. Brooks; The Gulf Stream; General Meteorological Project. Monthly Weather Review, March, 1930, 58:103-106.

[7] United States Treasury Department, Coast Guard Bulletin 18, International Ice Observations and Ice Patrol Service in the North Atlantic Ocean, Season of 1929. Government Printing Office, 1930.

[8] Reprinted from the Meteorological Magazine, London, August, 1930, pp. 169-170.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Apthorp, R. E.
Don't guess about the wind! [Salem.] n. d. [2 p. fold.] illus. 22 cm. [Circular describing the Apthorp wind-meter.]

Aurén, T. E.
Illumination from sun and sky in the neighbourhood of Stockholm in 1928. Stockholm. 1930. 24 p. illus. plates. 31 cm. (Medd. Stat. met.-hydrog. anst. Bd. 5. N: 4.)

Commonwealth solar observatory.
Memoir. Melbourne. 1928. no. 1. Luminosity of the night sky observed with a Rayleigh photometer at the Commonwealth solar observatory during the years 1926 and 1927. Melbourne. May, 1928. 29 p. figs. 31 cm.

Daniel Guggenheim fund for the promotion of aeronautics, inc.
Daniel Guggenheim international safe aircraft competition. Final report. January 31, 1930. New York City. [1930.] 147 p. illus. 28 cm.
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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING JULY, 1930

By IRVING F. HAND

For reference to descriptions of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this volume of the REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged higher than the normal intensity for July at Washington and Madison, and close to normal at Lincoln.

Table 2 shows an excess in the total radiation received on a horizontal surface at Washington, Madison, Lincoln, and New York, and a deficiency at Chicago, Fresno, and La Jolla for the month. Through the courtesy of Dr. O. J. Sieplein, director of the Belle Isle Observatory of the University of Miami, Fla., records of the total solar and sky radiation are added to the list of similar measurements published in Table 2. The instrumental equipment in use at this station consists of a Callendar recorder, together with a Callendar receiver having a quartz hemispherical cover. The latitude of the station is 25° 45′ N. and the longitude 80° 08′ W. The altitude of the receiver is close to sea level.

Skylight polarization measurements obtained on four days at Washington give a mean of 51 per cent and a maximum of 60 per cent on the 8th. At Madison measurements obtained on nine days give a mean of 61 per cent with a maximum of 68 per cent on the 30th. These are close to the corresponding averages for July at both stations.

TABLE 1.—*Solar radiation intensities during July, 1930*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
July 7	16.79				1.01						10.97
July 8	11.81		0.90	1.05	1.15	1.36					11.81
July 10	15.11				0.90	1.37					10.21
July 11	13.13				0.80						14.10
July 25	15.11			0.65	0.84	1.19					13.13
July 28	20.57				0.77						18.59
July 30	9.47					1.40	1.10	0.88	0.72		7.87
Means			(0.90)	(0.82)	0.91	1.33	(1.10)	(0.88)	(0.72)		
Departures			+0.23	+0.05	+0.01	+0.15	+0.12	+0.09	+0.04		

TABLE 1.—*Solar radiation intensities during July, 1930*—Contd.

Madison, Wis.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
July 2	9.14					1.27					8.48
July 7	17.37		0.90	1.05	1.22	1.38					10.59
July 12	11.38				0.95	1.18					18.59
July 14	7.87	0.89	0.97	1.10	1.24						7.57
July 15	8.18	0.73	0.85	0.99	1.12	1.36					8.18
July 16	8.81				1.03	1.24					10.59
July 24	13.61					1.29					13.13
July 25	14.60				1.07	1.23					15.11
July 28	16.78				1.10	1.33					12.24
July 29	11.38					1.37					9.47
July 30	10.59				1.26	1.46					9.47
July 31	9.83				1.09						10.21
Means		(0.81)	0.91	1.05	1.12	1.31					
Departures		+0.13	+0.13	+0.14	+0.06	+0.03					

Lincoln, Nebr.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
July 1	10.21						0.96	0.84	0.67		9.14
July 5	16.20		0.68	0.84	1.06	1.29	1.04	0.86	0.65		20.57
July 10	14.60			0.85	1.02	1.19					12.68
July 11	13.13		0.73	0.89	1.08	1.27					11.81
July 14	-7.87		0.88	1.01	1.17	1.41	1.15	0.87			7.57
July 15	7.57						1.00	0.78			8.81
July 16	9.83		0.78	0.91	1.07	1.32	1.02	0.78	0.64		10.59
July 17	8.48		0.79	0.91							9.83
July 19	10.59						0.97	0.81	0.67		10.59
July 31	11.38		0.75		1.06						16.79
Means			0.77	0.90	1.08	1.30	1.02	0.82	0.66		
Departures			-0.01	+0.01	±0.00	-0.02	-0.04	-0.06	-0.07		

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning	Average daily totals: Washington	Madison	Lincoln	Chicago	New York	Pittsburgh	Gainesville	Twin Falls	Fresno	La Jolla	Miami
1930											
July 2	592	523	649	392	467	557	570		645	310	432
July 9	561	538	609	380	404	538	547		650	525	511
July 16	461	525	576	436	383	482	607		702	501	552
July 23	509	558	556	424	376	528	649		713	518	574
	Departures from weekly normals										
July 2	+85	-9	+65	-72	+51				-54	-176	
July 9	+74	+7	+36	-32	-3				-45	+10	
July 16	-14	+14	+5	+16	-16				+1	-11	
July 23	+29	+62	+16	+12	-20				+15	+54	
Accumulated departures on July 1	+1,631	-406	+133	+1,883	-175				-1,590	-2,261	

POSITIONS AND AREAS OF SUN SPOTS, JULY, 1930

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, Perkins, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longitude	Latitude	Spot	Group	
1930	h	m	°	°	°			
July 1 (Naval Observatory)	10	16	−28.5	235.8	−25.5	6		
			−21.0	243.3	+13.5	18		
			+1.0	265.3	+13.0		31	55
July 2 (Naval Observatory)	11	1	−72.0	178.6	+7.0	31		
			−63.5	187.1	−6.5		31	
			−8.5	242.1	+13.5		9	
			+15.5	266.1	+12.5		3	74
July 3 (Naval Observatory)	11	1	−62.0	175.4	+7.5		46	
			−48.0	189.4	−6.5		15	
			−16.5	220.9	−9.5	3		
			+6.0	243.4	+13.5	6		
			+32.0	269.4	+13.0	6		76
July 4 (Naval Observatory)	10	35	−49.0	175.4	+8.4		28	
			−32.0	192.4	−6.0	12		40
July 5 (Naval Observatory)	11	10	−35.0	175.8	+7.0		9	
			−18.0	192.8	−7.0		18	27
July 6 (Naval Observatory)	11	28	−21.0	176.4	+8.0		15	
			−4.5	192.9	−7.0		12	27
July 7 (Naval Observatory)	10	47	−60.0	124.6	+21.0	31		
			−8.5	176.1	+7.5		22	
			+7.5	192.1	−7.5		12	65
July 8 (Naval Observatory)	11	33	+18.5	189.4	−6.0		28	28
July 9 (Naval Observatory)	10	42	−67.5	90.6	−5.5	9		
			+45.5	203.6	+4.0		170	179
July 10 (Naval Observatory)	10	45	−54.5	90.4	−5.0	6		
			+59.5	204.4	+4.0		201	207
July 11 (Naval Observatory)	11	54	+32.5	163.5	+12.0	6		
			+73.5	204.5	+4.5		216	222
July 12 (Naval Observatory)	10	22	−52.5	66.1	−7.0		46	
			−26.5	92.1	−0.5	6		52
July 13 (Naval Observatory)	10	25	−37.5	67.9	−7.0		108	108
July 14 (Naval Observatory)	14	3	−24.0	66.2	+7.5		170	
			−20.0	70.2	−7.0		9	179
July 15 (Naval Observatory)	10	53	−12.0	66.7	+7.5		170	
			−8.0	70.7	−7.5		18	188
July 16 (Naval Observatory)	10	34	−7.5	58.1	+7.0	2		
			+6.5	72.1	−7.0		170	172
July 17 (Naval Observatory)	10	33	+21.0	73.4	−7.0		139	139
July 18 (Naval Observatory)	10	53	+36.5	75.5	−6.0	123		123
July 19 (Naval Observatory)	10	46	+51.0	76.8	−5.5	108		108
July 20 (Naval Observatory)	10	46	−80.0	292.6	−10.0	15		
			+66.5	79.1	−6.0		123	138
July 21 (Naval Observatory)	10	49	−76.5	282.8	+3.0	62		
			−66.0	293.3	−10.0	9		
			+80.5	79.8	−6.0		139	210
July 22 (Naval Observatory)	10	19	−63.5	282.6	+3.0	62		
			−63.5	292.6	−10.0	12		
			−38.5	307.6	+16.0	3		77
July 23 (Naval Observatory)	11	19	−61.5	271.1	−12.5	46		
			−50.5	282.1	+2.5	9		
			−40.0	292.6	−10.0	6		61
July 24 (Naval Observatory)	10	17	−80.0	239.6	+2.5	77		
			−50.0	269.6	−13.0	6		
			−37.5	282.1	+2.5	37		120

Positions and areas of sun spots, July, 1930—Continued

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longitude	Latitude	Spot	Group	
1930	h	m	°	°	°			
July 25 (Naval Observatory)	11	10	−66.5	239.7	+2.5	62		
			−24.0	282.2	+3.0	31		93
July 26 (Naval Observatory)	10	48	−54.5	238.7	+2.5	62		
			−11.0	282.2	+3.0	15		77
July 27 (Naval Observatory)	10	28	−62.0	218.1	−4.5	3		
			−41.5	238.6	+2.0		77	
			−21.0	259.1	+13.0	2		
			+2.5	282.6	+3.0	9		91
July 28 (Naval Observatory)	10	50	−47.5	219.2	−4.5	3		
			−28.5	238.2	+1.0		93	
			−9.5	257.2	−11.5		18	
			−6.0	260.7	+12.5	6		
			+15.0	281.7	+3.5	6		126
July 29 (Naval Observatory)	10	48	−33.5	220.0	−5.0	3		
			−15.0	238.5	+1.5		62	
			+5.0	258.5	−11.0	3		
			+9.0	262.5	+12.0	3		
			+28.5	282.0	+3.5	3		74
July 30 (Naval Observatory)	10	47	−1.0	239.3	+1.5	34		34
July 31 (Naval Observatory)	11	11	−66.5	160.3	−9.0	9		
			+12.0	238.8	+1.5	25		34
Mean daily area for July								103

PROVISIONAL SUN-SPOT RELATIVE NUMBERS, JULY, 1930 [1]

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

July, 1930	Relative numbers	July, 1930	Relative numbers	July, 1930	Relative numbers
1	a 22	11		21	25
2	36	12	Ec 26	22	14
3	35	13	16	23	22
4	28	14	24	24	a 14
5	26	15	25	25	15
6	28	16	a 24	26	16
7	18	17	29	27	18
8	18	18	9	28	34
9	Wc 39	19	8	29	33
10	21	20	9	30	10
				31	19

Mean (30 days)=22.0.

[1] Dependent alone on observations at Zurich and its station at Arosa.
a=Passage of an average-sized group through the central meridian.
c=New formation of a large or average-sized center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.

AEROLOGICAL OBSERVATIONS

By RICHMOND T. ZOCH

Free-air temperatures were above normal at all stations excepting Groesbeck. At most levels the departures were large. (See Table 1.)

Free-air relative humidities were below normal at nearly all of the levels at all of the aerological stations. Free-air vapor pressures were also below normal at most of the levels at all the stations. Although the vapor pressures were also below normal at most of the levels at all the stations. The total precipitation for the month was considerably above normal at Due West and Royal Center. At the other stations the total precipitation for the month was below normal.

A comparison of Table 1 with Table 2 brings out the effect of nearby bodies of water on the free air temperatures and relative humidites. The effect is large in the lower levels but small in the higher levels.

Free-air resultant winds were mostly westerly in the lower levels. At the 1,500 meter level and above they were mostly northwesterly. In general it may be said that the resultant wind velocities were greater than for previous months of July and that the southerly component was less pronounced than in previous months of July.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during July, 1930*

TEMPERATURE (° C.)

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	26.9	+0.3	27.4	+0.5	23.4	+2.4	24.5	−2.1	25.8	+0.9
500	26.8	+1.9	25.4	+1.2	23.2	+2.6	23.7	−0.2	23.6	+1.5
1,000	24.3	+2.1	22.5	+1.5	21.0	+3.0	22.0	+.3	20.5	+1.9
1,500	20.6	+1.4	18.7	+1.1	18.3	+2.7	19.0	−0.1	16.9	+1.5
2,000	17.1	+0.9	15.2	+0.9	15.6	+2.7	15.7	−0.7	14.1	+1.6
2,500	13.8	+0.7	11.7	+0.6	12.1	+2.1	12.4	−1.1	11.4	+1.6
3,000	10.5	+0.6	8.3	+0.2	8.6	+1.5	9.6	−1.0	9.2	+2.1
4,000	4.2	+0.1	1.1	−1.2	1.9	+0.5	4.4	−0.2	4.1	+2.6
5,000	−0.8	+0.3							0.1	+4.8

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during July, 1930—Continued*

RELATIVE HUMIDITY (%)

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	62	−7	66	−1	58	−11	79	+4	54	−8
500	55	−11	64	−5	58	−10	75	−2	55	−9
1,000	52	−11	63	−7	53	−9	58	−9	55	−12
1,500	53	−9	65	−7	50	−8	57	−5	56	−10
2,000	53	−6	66	−6	46	−9	59	0	52	−10
2,500	48	−10	69	−3	45	−8	62	+4	46	−10
3,000	47	−11	68	−3	44	−7	58	+1	41	−9
4,000	46	−12	90	+22	42	−8	48	−12	31	−10
5,000	44	−12							45	+4

VAPOR PRESSURE (*mb.*)

Altitude (meters) m. s. l.	Broken Arrow, Okla. Mean	Departure from normal	Due West, S. C. Mean	Departure from normal	Ellendale, N. Dak. Mean	Departure from normal	Groesbeck, Tex. Mean	Departure from normal	Royal Center, Ind. Mean	Departure from normal
Surface	21.63	−2.40	23.55	+0.33	16.63	−0.48	24.40	−1.23	17.66	−1.83
500	19.21	−1.74	20.36	−0.02	16.49	−0.05	21.77	−0.71	15.81	−1.20
1,000	15.90	−1.13	15.69	−1.15	13.07	+0.23	15.16	−1.85	13.14	−1.23
1,500	13.05	−0.79	13.04	−1.10	10.34	+0.05	12.54	−0.95	10.96	−0.59
2,000	11.00	+0.04	10.73	−0.84	7.93	−0.35	10.60	−0.37	8.40	−0.36
2,500	7.53	−1.27	8.91	−0.42	6.02	−0.69	9.31	+0.28	6.69	+0.20
3,000	6.04	−1.14	7.74	+0.08	4.36	−1.04	7.55	−0.06	5.16	+0.29
4,000	4.14	−0.68	5.94	+0.96	2.20	−1.51	4.64	−1.12	3.25	+0.43
5,000	2.84	−0.68							2.64	+0.26

TABLE 2.—*Free-air data obtained at naval air stations during July, 1930*

Altitude (meters) m. s. l.	TEMPERATURE (°C.)					RELATIVE HUMIDITY (%)				
	Hampton Roads, Va.	Pensacola, Fla.	San Diego, Calif.	Seattle, Wash.	Washington, D. C.	Hampton Roads, Va.	Pensacola, Fla.	San Diego, Calif.	Seattle, Wash.	Washington, D. C.
Surface	26.3	26.3	23.3	18.1	25.0	69	85	68	61	66
500	23.7	24.3	20.9	14.1	22.6	64	79	67	70	62
1,000	21.5	22.8	24.0	11.8	20.8	54	70	38	74	56
2,000	14.6	16.7	20.7	8.9	15.0	62	67	26	52	53
3,000	8.5	10.5	12.2	4.9	9.3	60	68	39	42	49
4,000				−1.1	3.4				48	43
5,000					−2.0					43

TABLE 3.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a. m. (E. S. T.) during July, 1930*

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,873 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°	
Surface	S 14 W	1.6	S 7 W	2.0	N 74 W	2.2	N 86 W	1.2	N 40 W	1.5
500	S 34 W	7.3	S 47 W	3.7			N 57 W	4.6	N 40 W	1.3
1,000	S 44 W	8.0	N 80 W	3.9			N 55 W	4.3	S 83 W	2.6
1,500	S 45 W	4.6	N 67 W	5.3			N 57 W	4.3	N 69 W	4.6
2,000	S 60 W	2.4	N 70 W	8.0	N 82 W	3.8	N 62 W	4.3	N 58 W	6.0
2,500	S 69 W	2.4	N 75 W	8.7	S 54 W	4.2	N 68 W	3.8	N 59 W	7.4
3,000	S 65 W	2.3	N 69 W	6.7	S 56 W	3.7	N 69 W	3.8	N 67 W	9.3
4,000	S 47 E	0.6	N 72 W	9.6	S 83 W	2.3	N 62 W	4.0	N 71 W	10.9
5,000	S 88 E	1.6			N 79 W	4.0	N 59 W	3.8	N 70 W	12.6

Altitude (meters) m. s. l.	Groesbeck, Tex. (141 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (65 meters)		Key West, Fla. (11 meters)		Los Angeles, Calif. (145 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°	
Surface	S 19 W	1.5	S 85 W	0.4	S 55 W	2.9	S 72 E	2.3	N 51 W	1.8
500	S 42 W	8.6			S 72 W	6.5	S 69 E	5.0	N 86 E	1.0
1,000	S 26 W	6.7	S 72 W	1.3	S 68 W	5.8	S 61 E	5.1	N 84 E	1.1
1,500	S 1 W	4.9	N 67 W	3.2	S 65 W	4.1	S 62 E	4.5	N 67 W	1.5
2,000	S 11 E	4.5	N 79 W	3.8	S 68 W	2.7	S 65 E	3.8	S 77 W	2.7
2,500	S 27 E	3.6	N 87 W	5.4	S 39 W	2.4	S 64 E	3.5	S 45 W	3.2
3,000	S 29 E	3.5	S 81 W	7.2	S 24 W	2.1	S 59 E	3.6	S 29 W	3.6
4,000	S 38 E	3.6	S 80 W	10.1	S 10 W	1.9	S 56 E	3.3	S 17 W	3.2
5,000	S 48 W	3.6	S 81 W	13.5	S 1 W	0.4	S 80 E	3.6		

TABLE 3.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a. m. (E. S. T.) during July, 1930*—Continued

Altitude (meters) m. s. l.	Medford, Oreg. (410 meters)		Memphis, Tenn. (145 meters)		New Orleans, La. (25 meters)		Omaha, Nebr. (321 meters)		Royal Center, Ind. (225 meters)		Salt Lake City, Utah (1,294 meters)		San Francisco, Calif. (8 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. (14 meters)		Washington, D. C. (10 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°	
Surface	S 24 W	0.4	S 36 W	0.9	N 67 W	0.6	S 23 E	0.9	S 8 E	0.8	S 26 E	3.3	N 33 E	0.1	N 60 W	0.7	S 19 E	0.3	N 86 W	0.4
500	S 72 W	0.9	N 81 W	3.2	N 70 W	4.2	S 26 W	4.6	S 63 W	3.2	----	----	S 7 W	2.3	N 56 W	3.2	S 5 W	0.7	N 62 W	4.2
1,000	N 61 W	1.5	N 72 W	4.1	N 64 W	2.8	S 62 W	8.6	N 72 W	5.4	----	----	N 31 W	1.7	N 62 W	4.6	N 7 W	0.3	N 56 W	6.5
1,500	N	0.8	N 61 W	4.1	N 6 W	0.6	S 75 W	6.7	N 56 W	5.7	S 20 E	5.7	N 47 E	0.7	N 62 W	7.6	N 25 W	1.0	N 58 W	6.6
2,000	N 73 E	0.4	N 63 W	3.4	N 84 E	1.1	S 84 W	5.5	N 60 W	7.5	S 2 W	5.4	S 87 E	1.0	N 62 W	8.9	S 2 E	0.9	N 60 W	7.9
2,500	S 31 W	3.5	N 62 W	2.4	S 69 E	2.1	S 89 W	4.4	N 51 W	8.7	S 22 W	3.1	----	----	N 60 W	10.0	S 29 W	2.4	N 69 W	8.0
3,000	S 30 W	5.5	N 74 W	1.8	S 74 E	2.5	S 87 W	4.8	N 53 W	9.7	S 48 W	3.0	----	----	N 57 W	10.6	S 33 W	2.9	N 64 W	8.5
4,000	S 36 W	7.9	N 58 W	3.0	S 70 E	2.8	N 75 W	6.2	N 53 W	11.5	S 42 W	3.9	----	----	N 53 W	12.0	S 49 W	5.1	N 65 W	9.7
5,000	----	----	N 55 W	3.5	N 78 E	3.4	N 75 W	7.4	N 54 W	9.7	S 33 W	4.1	----	----	N 47 W	13.6	S 47 W	8.5	----	----

TABLE 4.—*Observations by means of kites, captive and limited-height sounding balloons during July, 1930*

	Broken Arrow, Okla.	Due West, S. C.	Ellendale, N. Dak	Groesbeck, Tex.	Royal Center, Ind.
Mean altitudes (meters), m. s. l., reached during month	3,058	2,502	3,074	2,226	3,347
Maximum altitude (meters), m. s. l., reached and date	[1] 6,397	[2] 4,585	[3] 4,939	[4] 4,029	[5] 7,171
Number of flights made	31	29	32	25	28
Number of days on which flights were made	30	29	29	25	27

[1] 30th. [2] 11th. [3] 25th. [4] 23rd. [5] 3d.

In addition to the above there were approximately 125 pilot balloon observations made daily at 53 Weather Bureau stations in the United States.

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By H. C. HUNTER

GENERAL SUMMARY

July was one of the hottest months in the history of the Weather Bureau, also one of the driest summer months Only small portions of the country had either more rain or lower average temperature than the mean of other Julys. The dryness was intense mainly in those east-central and south-central districts which were sorely in need of moisture when the month began, but other districts, especially to northward and westward, received very little rainfall in July. The heat was felt widely for considerable periods of time, and high marks occurred at great numbers of stations. In the Missouri Valley every first-order station recorded 100° or higher; in the upper Mississippi Valley, 9 out of 15; in the Ohio Valley and Tennessee, 14 out of 16; in the east Gulf area, 9 out of 12; and in the Middle Atlantic States, 11 out of 18.

TEMPERATURE

The first half was mainly warmer than normal, save in the Lake region and the Northeastern States and in portions of the Southwest. Unusual heat prevailed in the Plains and the northern Rocky Mountain region, also after the 5th in the central valleys and most of the Southeast.

The final half was a period of record-breaking heat in many northern and middle portions east of the Rocky Mountains, but in the southern portion and the far West the temperatures usually averaged about normal.

For July as a whole the temperature averaged above normal in nearly all sections, only five States of the far West, in addition to New York and New England, finding the month of but normal temperature or slightly lower. Generally from the interior portions of the Middle and East Gulf States northwestward to the middle and northern Plains the month averaged 4° to 7° hotter than normal. It was among the hottest ever recorded from the northern and middle Plains southeastward to the southern Middle Atlantic States and the South Atlantic and East Gulf States, though stations close to the seacoast usually found it from 1° to 4° less hot than the hottest month of previous record.

At Little Rock, Ark., the month was 1.4° hotter than any previous month in a 50-year record; at Tampa, Fla., the month was 0.5° hotter than any previous July in a 40-year record, though failing to equal August, 1924; at Chattanooga, Tenn., the month was warmer than any August or any previous July in a record of 51 years, though not quite so hot as September, 1925; and at Atlantic City, N. J., the month was exceeded by but two previous months in a record of 56 years. At Washington, D. C., the month was the hottest in almost 60 years, save July, 1872, which slightly exceeded it, and Julys of 1876 and 1887, which practically equaled it. Numerous places with records for 20 to 40 years found no other month so hot.

From Pennsylvania northeastward and in the Lake region the July average was not extraordinary, and this was the case over much of the Southwest and the far West, save near the southern California coast.

Remarkably high temperatures were experienced during several periods of the month. The highest marks in portions of the northern Plains and in much of the Southeast occurred about the 12th. In the southern portion of the Lake region, the Middle Atlantic States and much of the Ohio Valley the top marks were noted about the

20th. The last week of July brought the highest readings to most of the middle Plains and the central valleys.

About 10 stations, with records exceeding 50 years, attained new high temperature records during the month, and a large number of places with shorter records.

Passing to sections where the temperatures were not so noteworthy, it is found that the Northeast and the northern portion of the Lake region scored their highest marks of the month about the 19th to 21st, but the far Western States on various dates.

The lowest readings of July occurred early in the month at very many stations, particularly in the Southwest and the Southeast, but about the 14th to 17th at most places from the middle and northern Plains eastward to the Atlantic coast.

PRECIPITATION

The rainfall was poorly distributed over the country, and such amounts as did fall were not well distributed through the month. The country as a whole has seldom received less rain in a summer month.

The first half of the month usually was not marked by so scanty rainfall as the second half, and of the first half the opening week was generally the time of more plentiful rains. However, the latter half brought as much rain as the first half, or even more, to some portions of the Plains and the far Southwest, and notably to most of the East Gulf and South Atlantic States. From Alabama and northern Florida to South Carolina there usually were liberal rains about the 17th, and again during the period from the 23d to the 29th.

The aggregate July rainfall was less than normal in all sections of the country except some small areas along the Atlantic coast or in the Lake region, and from Wyoming and southeastern Idaho southward to the central parts of Arizona and New Mexico. Portions of this last-named region received more than twice as much rain as the average quantities of previous July records.

In the many regions where the rainfall was less than normal, several stand out as having but a small percentage of the normal. Of the east-central, central, south-central, and southwestern sections large portions measured only from 25 to 50 per cent of the normal, while a number of areas in the central and lower Mississippi Valley and the Red River Valley received less than 5 per cent. Practically all of the Pacific States received no precipitation at all during the month, but a great part of this area normally is without rain in July.

Considering those districts which had entered July with severe need of rains, it is found that the scarcity of rainfall during July was very marked over the Ohio and the middle and lower Mississippi Valleys, also over much of eastern and north-central Texas and most of the Dakotas and western Minnesota. Likewise the interior area of the Middle Atlantic States from central Pennsylvania southward continued exceedingly dry.

Marked shortages occurred in July in many districts which came to the end of June with moderate or ample soil moisture, namely—southern Michigan and adjacent portions of Ohio and Indiana, practically all parts of Missouri, Illinois, Iowa, and Minnesota which had fared well before July, western and northern Wisconsin, and the central plains.

Over a considerable portion of the drought-stricken area there had been scanty precipitation during all months or almost all since 1930 began, or even from the late months of 1929. This had resulted in deficient supplies of ground water and in scanty stream flow.

The most severe drought conditions in the normally wetter part of the country were to be found in a very large portion of the Ohio River drainage area and in most of the area within 150 miles of the lower course of the Mississippi River. Here both June and July failed to bring as much as half of the normal rainfall; and in large portions of the areas specified the situation was considerably worse than even this implies. Less than one-third of the combined normal amount for June and July was received in southern Illinois, southeastern Missouri, western Tennessee, northeastern, central, and southern Arkansas, northern and central Mississippi, northern and southwestern Louisiana, and much of eastern Texas.

Among well-known stations of the afflicted area, these cases are cited: Cairo, Ill., received in June and July together but 1.63 inches; Memphis, Tenn., 0.33 inch; Little Rock, Ark., 0.13 inch; Vicksburg, Miss., 0.71 inch; Shreveport, La., 0.97 inch; and Galveston, Tex., 0.32 inch.

SUNSHINE AND RELATIVE HUMIDITY

The month brought considerably more clear weather than usual over a great portion of the country. The amount of sunshine was particularly large in the Ohio and Mississippi Valleys and the Plains States, but was somewhat greater than usual in July in substantially all of the Atlantic States.

The relative humidity, as generally happens, was deficient in most States where the sunshine was more than usual, so that nearly the entire country showed a lower percentage of humidity than the average of previous Julys. From the upper Ohio Valley and the southern Appalachian region westward and northwestward to the western plains the deficiency was 15 per cent or more and in parts of the central valleys and the Ozark region the deficiencies were more than 20 per cent.

The month showed somewhat greater relative humidity than normal over most of the southern Rocky Mountain and Plateau regions, and likewise in northeastern New York and northern New England.

The remarkably low humidity in the area where temperatures were so high made the situation worse for crops than it would otherwise have been; and the loss of moisture severely affected crops in all but the very few small areas where substantial showers occurred to provide new supplies of moisture to plants. However, for men and animals the low humidity made the suffering from heat less intense.

SEVERE LOCAL STORMS, JULY, 1930

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Devol, Okla	1	7:15 a. m.	300		$2,000	Wind	Property, other than crops, damaged; 1 person injured; path 400 yards long.	Official, U. S. Weather Bureau.
Raton, N. Mex., and vicinity.	1	1-3 p. m.	1-3 mi.		12,000	Hail	Roofs, windows, auto tops, and crops severely damaged.	Do.
Baileyville, Kans. (near)	3	5:30 a. m.	1,500			Hail	Roofs pierced; trees stripped; path 4 miles long	Do.
Findlay, Ohio	4					Probably tornado.	Buildings and trees damaged	Do.
Grundy County, Iowa	5	3 a. m.	2 mi.		3,000	Hail	Character of damage not reported; path 5 miles long.	Do.
Linn County, Iowa	5	4 a. m.	880		1,500	Hail and rain	No details reported; path 4 miles long	Do.
Mahaska County, Iowa	5	5 a. m.			1,000	Tornado	No details reported; path 1.5 miles long	Do.
Manitowoc, Wis	5				1,500	Hail	Windows and greenhouses damaged	Do.
Birdsboro, Pa	6	5 p. m.				Rain, wind, and hail.	1 building blown down, several damaged; grain injured.	Do.
Mifflintown, Pa. (near)	6	5-5:30 p.m.			10,000	Electrical, wind and hail.	Trees uprooted; 2 barns burned	Do.
Marion County, Kans. (near)	6	5:30 p. m.	2 mi.		7,500	Hail	Chief damage to crops; path 4 miles long	Do.
Ulster and Dutchess Counties, N. Y.	6	6 p. m.	1,760		10,000	do	Much damage to fruits and tomatoes	Do.
Evansville, Ind., and vicinity.	6	10:30 p. m.				Thunderstorm, wind, and hail.	Power lines damaged; basements flooded, shade trees broken; 1 barn destroyed, crops injured.	Do.
Clarence, N. Y	6	P. m.			28,000	Electrical	Clubhouse burned	Do.
Wayne and Susquehanna Counties, Pa.	6	do				Hail	Considerable crop damage; poultry injured	Do.
Frazier, Miles City, and Poplar to Brockton, Mont.	8				17,000	Hail and wind	Crops damaged; telephone poles blown down	Do.
Santa Rosa, N. Mex. (near)	8	P. m.	1,760		1,100	Hail	175 sheep killed	Do.
Mena, Ark	8					Wind	Considerable damage to small buildings, roofs, trees, and plate glass windows.	Do.
Georgetown, Md., and vicinity.	9	11 p. m.	8 mi.		50,000	Hail	Greatest damage to corn and tomatoes; path 12 miles long.	Do.
Cumberland, Johnson, Sampson, and Wayne Counties, N. C.	9				150,000	do	Character of damage not reported.	Do.
Morristown, N. Y	9		3 mi.		37,000	do	All crops hurt; some damage to buildings.	Do.
Delmar, Del	10	1 a. m.	2 mi.			do	All crops destroyed on some farms; path 6 miles long.	Do.
Ingomar, Mont., and vicinity.	10				1,000	Wind	Character of damage not reported.	Do.
Nashville, Tenn	10				5,000	do	A glider and plane partially wrecked; 400 telephones out of commission.	Do.
Neillsville, Wis. (near)	10				5,000	Severe squall	Two silos and other farm buildings damaged	Do.
Lovell Field, McCallie Lake, Alton Park and St. Elmo, Tenn.	11	9:20 a. m.				Wind	Trees and wires blown down; roof of hangar partially blown off.	Do.
Daviess and Greene Counties, Ind.	11				10,000	do	Crops, buildings, and wires damaged	Do.
East Hartford, Conn	11					Wind, hail, and rain.	Heavy damage to tobacco; traffic temporarily halted; streets flooded.	Hartford Times (Conn.).
Evansville, Ind	11				1,000	Tornado	1 house moved from foundation; others damaged; garage wrecked; trees uprooted.	Official, U. S. Weather Bureau.
Headland, Ala	11				13,000	Hail	Damage chiefly to crops	Do.
Logansport and Lucerne, Ind.	11					Wind	Wires blown down; trees and roofs damaged	Do.
Nashville, Tenn	13	1:08 a. m.			3,500	Thunderstorm and wind.	Large electric sign completely wrecked; trees and billboards blown down.	Do.
Eastover, S. C. (near)	13	1 p. m.			5,000	Electrical	Residence burned	Do.
Cedaridge, Colo	17	3-4 p. m.	2,640		40,000	Hail	Severe damage to crops	Do.
Tama County, Iowa	19	6 p. m.			5,000	Tornado	Character of damage not reported	Do.
Chamberland and Kimball, S. Dak.	19	10:30 p. m.			31,000	Hail and wind	Buildings destroyed or damaged; crops ruined; greatest damage in Kimball.	Do.
Huron, S. D. (southeast of)	19	11:55 p. m.			8,000	Wind	Buildings wrecked	Do.
South Fork, Colo. (near)	19	P. m.				Hail	300 acres of lettuce totally destroyed	Do.
Marathon, Portage and Waupaca Counties, Wis.	20	4.30 p. m.			15,500	Tornado and thunderstorm.	3 barns wrecked; other buildings damaged; minor crop injury; tornado near Dancy.	Do.
Lincoln, Nebr	20	4.40 p. m.			2,000	Wind	Several farm buildings damaged; trees uprooted; telephone poles blown down; small hangar wrecked.	Do.
Delaware County, Iowa	20	6 p. m.			8,200	Tornado and wind	Character of damage not reported; path 2 miles long.	Do.
Tama County, Iowa	20	do			8,000	Tornado, wind, and hail.	No details reported	Do.
McCook, Nebr	20	6.45-7.05 p. m.				Wind and hail	Hangar demolished and 6 planes wrecked; several buildings damaged; many trees uprooted; corn injured.	Do.
Chazy, N. Y	20	P. m.				Hail	Considerable damage to field crops, young apple trees and gardens.	Do.
Allentown, Pa	21	5 p. m.			20,000	Electrical and wind.	Many buildings unroofed	Do.
Sidney, Ohio (near)	21					Electrical and probably tornado.	2 barns burned; some damage to other property	Do.
Logansport, Ind	21				7,500	Wind	Considerable property damage	Do.
Red Lion to Seaside Park, N. J.	21				75,000	Tornado	Heavy property damage, chiefly at Seaside Park	Do.
Chester, Bucks, Montgomery, and Northampton Counties, Pa.	22	3-6 p. m.			200,000	Wind, hail, and electrical.	Property of all kinds badly damaged	Do.
Weimer, Tex	22	5 p. m.	33		100	Tornado	Small buildings wrecked	Do.
Burlington to New Brunswick, N. J.	22			2	200,000	Thunderstorm and wind.	Heavy property damage over path about 37 miles long.	Do.
Baltimore, Md	22			1		do	A few houses unroofed	Do.
Athens, Tenn	23					Wind	Trees and outbuildings blown down; several horses killed.	Do.
Omah, Wash	23				8,000	Hail	Orchards injured	Do.
Shawano and Oconto Counties, Wis.	24	3 p. m.			20,000	do	Windows broken; poultry killed, crops beaten	Do.
New Danville, Pa., and vicinity.	24	3-4 p. m.			60,000	Wind	Property of various kinds damaged	Do.

[1] "Mi." signifies miles instead of yards.

Severe local storms, July, 1930—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Pena Blanca, N. Mex.	24	P. m.	1,760		$10,000	Cloudburst	12 homes demolished; land covered with sand	Official, U. S. Weather Bureau.
Rockland and Arbon Valley, Power County, Idaho.	25	3-4 p. m.	2-3 mi.		50,000	Hail	Large wheat fields completely ruined	Do.
Macon, Ga.	25	3:33 p. m.				Thunderstorm, wind, and rain.	Trees uprooted; telephone poles blown down; chimneys overturned. Some damage by lightning.	Do.
Benton and Buchanan Counties, Iowa.	25	6 p. m.			73,000	Wind and hail	Character of damage not reported	Do.
Story County, Iowa	26	9:30 a. m.	1,760		500	Tornado	No details reported	Do.
Boone, Hancock, and Kossuth Counties, Iowa.	26				70,500	Wind and hail	do	Do.
Coddington, Wis.	27	1:30 a. m.	880		10,000	Probably a tornado.	5 barns wrecked; other buildings damaged	Do.
Wright and Ida Counties, Iowa.	27	7 p. m.			12,000	Wind and hail	No details reported	Do.
Stoughton and Oregon, Wis.	27	11 p. m.	4 mi.		30,000	Hail	Chief damage to crops; path 9 miles long	Do.
Appelton, Wis. (near)	27			2		Thundersquall	Power lines blown down	Do.
Bruce to Ladysmith, Wis.	27				100,000	Thunderstorm and wind.	Many barns and silos partially or completely wrecked; other buildings damaged.	Do.
Ellsworth, Wis. (near)	27		6 mi.		30,000	Squall	A number of barns and silos demolished	Do.
Rice Lake, Wis.	27			1		Thundersquall	Electric wires blown down	Do.
Wausau, Wis., and vicinity.	27				10,000	Wind and rain	Public utilities companies suffer losses; several barns blown down and roofs damaged.	Do.
Trenton, S. C., and vicinity.	27				7,000	Electrical	Home burned; mule killed	Do.
Dunkirk, N. Y.	28	P. m.		16		Thundersquall	Steamer George W. Whelan sank, drowning part of crew.	Do.
Greenville, S. C.	28				10,000	Thunderstorm	Duke Power Plant damaged	Do.
Rock Hill, S. C. (near)	28	P. m.			3,000	Electrical	Barn and contents burned; 6 mules killed	Do.
Greenville, Miss.	29	4 p. m.	220		5,000	Thundersquall	Character of damage not reported	Do.
Greenville, Tex. (near)	29	5 p. m.				Tornado	Boathouses, bathhouses and outbuildings overturned or damaged.	Do.
Dandridge and Murfreesboro, Tenn.	29					Wind	Trees and chimneys blown over; crops injured	Do.
Pittsylvania County, Pa. (north-central).	29					Hail	Crops destroyed over small area	Do.
Groveton, Tex. (near)	30	6 p. m.	2,640			Wind	Roofs torn off; crops badly damaged	Do.
Valley View, Tex.	30	do				Wind and hail	Outbuildings and crops damaged	Do.
Wichita Falls, Tex.	30	6.30 p. m.	332			Wind squall	2 houses unroofed; small buildings damaged; poultry killed.	Do.
Diboll, Tex.	30	10 p. m.				Wind	Considerable damage to buildings; corn hurt	Do.
LaSalle and Grant Parishes, La.	31	3-5 p. m.	2 mi.		60,000	Severe thundersquall, tornadic characteristics at times.	A number of buildings blown down; timber and oil derricks damaged; path 20 miles long.	Do.

RIVERS AND FLOODS

By R. E. SPENCER

As part of his report on the results of the Red River flood of May, 1930, Mr. R. A. Dyke, of the Weather Bureau office at New Orleans, La., submits the following tabulation from a report of the New Orleans office of the Bureau of Agricultural Economics, United States Department of Agriculture. (The figures include the Louisiana acreage within both the Shreveport and the New Orleans river districts):

Crop acreage destroyed by flood waters in the Red River Valley in Louisiana, in May, 1930, acreage subsequently replanted, and percent replanted

Crop	Acreage destroyed by flood	Acreage replanted	Per cent replanted
Cotton	95,400	58,085	60.9
Corn	34,335	43,948	130.0
Oats	1,360	0	0.0
Tame hay	9,783	7,050	72.1
Irish potatoes	450	80	17.8
Sweetpotatoes	700	989	141.3
Peanuts	140	25	17.9
Sugarcane	520	0	0.0
Truck crops	375	340	90.7
Total	143,063	110,517	77.25

Number of head of livestock destroyed by the flood: Horses, 8; mules, 5; cattle, 112; swine, 215; sheep, 100; goats, 475; poultry, 580. Nearly all the cattle drowned were in Caddo Parish; nearly half of the swine were drowned in Avoyelles Parish; all the sheep and nearly all the goats were drowned in Natchitoches Parish.

The crop acreage destroyed is divided by parishes as follows:

Bossier	6,460	Winn	7,330
Caddo	26,460	Natchitoches	55,005
De Soto	3,890	Avoyelles	1,410
Red River	33,175	Grant	6,300
Webster	1,025	Rapides	1,865
Bienville	143		

Mr. Dyke's report continues—

Approximately half of the inundated crop acreage of 33,920 in Caddo and Bossier Parishes is in the Shreveport river district. Confining the estimated losses to the New Orleans district, the total agricultural loss, exclusive of farm equipment, approximated $1,235,000 for crops and $6,000 for livestock. Cotton and corn losses are estimated at $1,073,600, with oats, hay, potatoes, sweet potatoes, sugar cane, and truck making up the remainder of the crop losses.

There were also some losses of household goods, unestimated. There was some damage to highways, and highway traffic in much of the valley was interrupted for a few weeks. More than 10,000 persons were rendered temporarily homeless, about 7,500 being cared for in refugee camps. Others, remaining in or near their homes, were supplied with provisions by boat. The loss of life, amounting to about nine persons in the State, in most cases was only indirectly connected with the flood, occurring mainly on bayous in the area, where efforts were being made to remove livestock or to travel by boat.

An estimate of the money value of the Weather Bureau flood forecasts is impracticable from the data available. But it is known that general heed was given to the warnings and the active efforts made to save livestock and other property resulted in large savings.

Excepting that referred to in the paper immediately following this report, no flood damage of importance is reported for July. A discussion of the effect of the drought upon stream stages will appear in the August

issue of this Review. The usual table of flood stages and dates for July follows:

[All dates in July unless otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
MISSISSIPPI DRAINAGE					
	Feet			*Feet*	
Canadian: Logan, N. Mex	4	14	16	6.0	14
		23	25	7.0	23
WEST GULF DRAINAGE					
Trinity: Dallas, Tex	25	27	(1)	[2] 27.2	31
Rio Grande: San Marcial, N. Mex	3	15	15	3.4	15
		23	25	3.9	23
PACIFIC DRAINAGE					
Colorado: Parker, Ariz	7	(3)	(1)	10.5	June 7, 17-20

[1] Continued at end of month.
[2] Artificial stage, caused by construction of temporary dam necessary for levee work below gage.
[3] Continued from last month.

The following discussion of effects of the heavy and concentrated summer-time rains of the Rocky Mountain region is submitted by Mr. J. Cecil Alter of the Weather Bureau office at Salt Lake City, Utah:

A series of sudden, rapid, local showers during the evening of July 10th sent short-lived mud streams dashing out of a number of steep gullies and ravines on the face of the Wasatch Mountains between Centerville and Farmington, Utah, also from side gullies in Spanish Fork Canyon, Parleys Canyon near Salt Lake City, and in Weber Canyon (near Ogden) in the vicinity of Devils Gate, causing altogether a property loss and repair expense approaching $100,000 in a comparatively few minutes.

Several mud washes crossed the highway in Parleys Canyon, stalling automobiles for a few hours, and similar damage was done in Spanish Fork Canyon, southeast of Spanish Fork town. One short slide spent itself on the higher land above Centerville; but three other washes toward Farmington left masses of soil, sand, gravel, rocks, and bowlders more than a mile in length, largely through farming sections, ranging from a few yards to nearly a thousand feet in width and from one to twelve feet in depth, resulting in property damage of about $50,000. The paved highway was cleared only after a week's work with men, teams, and steam shovels, the three cuts being from 300 to 500 feet in length and from 1 to 10 feet deep.

Toward the terminals of these earth washes fairly clean sand and soil buried this season's crops and damaged the land more or less, but farther up a considerable acreage of farming land was ruined for agricultural or residence purposes by heavy deposits of soil, rocks, and bowlders, some of them from four to six feet through, besides destroying the growing crops, bearing orchards, fences, irrigation waterways, barns, siloes, coops, and other structures, including two or three brick cottages which were so badly flooded, damaged, or buried as to necessitate abandonment along with the land. A small loss of poultry, pigs, and sheep occurred, along with some farming implements and vehicles. Three automobiles on the State highway were caught in one flood at South Farmington and were buried to the radiator tops, though the passengers escaped safely.

A large quantity of earth was deposited across the highway and railroad track just within the mouth of Weber Canyon, but the largest slide of the series occurred near Devils Gate, where an immense mass of débris from an adjacent gully piled into the canyon 35 feet high and 400 feet wide, extending nearly across the canyon. The Weber River, one of the State's largest, was completely dammed and the entire stream diverted onto the railroad and highway a distance of several hundred feet. It required the continuous effort of steam shovels, drag lines, teams, and laborers more than a week to turn the stream back into its natural channel and clear and repair the roadways.

Near by two loaded trucks on the highway and one passenger automobile were half buried, but later excavated safely. Just after the river broke over the artificial dam the stream was turbulent for a few hours, washing the railroad grade pretty badly in one place, leaving the rails hanging in space; and many fish were drowned in the roily waters. The supply flume for the Davis and Weber Counties canal system was broken by the mud slide, and the intake ditches farther down were silted full; but the rain on the crops was about equal to the watering missed while cleaning and repairing the damaged lines. Other minor damages were reported farther north, in Cache Valley.

These mud slides were not landslides, but mere washes, resulting from the sudden, rapid, and rather heavy downpours of rain, on very dry, steep, scantily covered slopes, which had not been washed recently. The three larger mud runs near Farmington were on the crests of broad, well developed talus cones which have doubtless resulted from similar washes at intervals through the ages past. However, other near-by gullys, ravines, and canyons some of which have only in recent years disgorged similar or worse masses of earth, failed to do so in this storm, indicating the apparently limited extent of the areas of heaviest rainfall.

The storm was rather general in northern Utah, though precipitation amounts were mostly only moderate, ranging from 0.35 to 0.85 inch at the measuring stations Losses aggregating $44,000 have been estimated in the Centerville-Farmington district; and the cost of clearing the highways and railroads and making repairs is considered to have exceeded $50,000.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, JULY, 1930

By J. B. KINCER

General summary.—The outstanding feature of the month's weather was the development of severely droughty conditions over central parts of the country, attended by extremely high temperatures.

During the first decade generally good harvest weather prevailed in the main Winter Wheat Belt, with much sunshine and only local showers, but in the more Northwestern States high temperatures and dry weather were unfavorable. In the South local showers were beneficial, but a good, general rain was needed over this area, while droughty conditions continued in the east-central sections, principally in Kentucky, West Virginia, and adjacent States. Most crops needed a generous rain throughout central areas of the country.

During the second and last decades there was no relief from the drought, with high temperatures serving to intensify conditions in most places. Local showers afforded some relief, but crops, in general, suffered severely from extreme heat and the absence of rain. During the month temperatures of 100°, or higher, were reported from first-order Weather Bureau stations on 4 to 6 days in the Middle Atlantic sections and from 6 to as many as 15 days in nearly all sections from the northern portions of Alabama, Mississippi, Louisiana, and northeastern Texas northward over the Ohio and Mississippi Valleys and Plains States to eastern South Dakota. The latter part of the month lower temperatures overspread much of the country, but were beneficial only in checking the rapid deterioration of growing crops, while at the close generous rains were needed badly to replenish water supplies and aid crops that were not too far gone.

Small grains.—Harvesting and threshing winter wheat progressed throughout the month, with practically no interruption by rain. The extreme heat was very unfavorable for men and horses, however, with reports of many horses dying in some central and upper Mississippi Valley areas. The weather during the latter part of the winter wheat season was practically ideal for gathering the grain in excellent condition. Some damage to spring wheat occurred through deficient moisture and hot winds, but at the close of the month harvesting the early crop was well advanced. Oat harvest progressed favorably, with threshing returns varying widely; at some places results were better than anticipated. Flax showed some injury from dryness, particularly the late crop, while some abandonment of rice fields was necessary in Arkansas, although showers were helpful elsewhere. At the close of the month plowing and disking for winter wheat was making excellent advance in Kansas.

Corn.—The weather during the month was especially unfavorable for the corn crop, with general drought

prevailing, aggravated by the extremely high temperatures. At the beginning of the month conditions were already serious in the eastern Corn Belt, especially in southern Indiana and Illinois, Ohio, and most of Kentucky; in this area upland corn was fired, while lowland needed rain badly. The continued absence of rain caused most upland corn to deteriorate badly throughout the belt, and at the close of the month much was burned beyond recovery, especially in the Southwest and the Ohio Valley. By the close of the month the continued drought had caused widespread injury to corn, with the larger part of the crop in Missouri ruined and much unfit even for silage. In southwestern Iowa the crop deteriorated badly, with many tassels and leaves burned white, while in the immediate Ohio River region much corn was beyond recovery. In the northern parts of Indiana and Illinois conditions were not so serious and were still fair in Nebraska and parts of Kansas, although rain was urgently needed.

Cotton.—Although conditions were fairly favorable at the beginning of the month in the western states of the Cotton Belt, the drought became progressively worse and at its close most of this section was unfavorably dry. In Texas progress of cotton in the southern third was mostly good throughout the month, except for some shedding, but in the northern two-thirds of the State deterioration had set in at the close, with complaints of small plants bolls shedding, and premature opening. Cotton made very little growth in Oklahoma also, with wilting and some shedding reported, while the general condition of the crop was only poor to fairly good at the close of the month. In central States of the belt most upland cotton made but little growth, except where local showers occurred and on some lowlands. In the Atlantic States conditions were much better, although rain was beginning to be needed in places at the close of the month. The first bale was marketed from Georgia toward the close, while marketing had advanced northward to Rusk County in Texas.

Miscellaneous.—At the close of the month pastures and meadows were badly burned and brown practically everywhere east of the Rocky Mountains and were affording little, if any, feed; water was scanty everywhere in this area. In the southwestern range country conditions were good, with the range, stock, and water supply largely excellent.

Minor crops deteriorated badly due to the dry weather, except for local areas where showers occurred. Tobacco was also seriously harmed in the dry regions, with forced cutting under way in northern Kentucky at the close of the month. Fruits shriveled under the intense heat, but most crops were apparently holding up fairly well.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

While the absence of heavy weather was not so marked as during the preceding month, the number of days with gales was below the normal over the greater part of the ocean and the number of gale reports received less than usual. The outstanding feature of the month was the unusual strength of the east and northeast trades in the southwestern section of the Caribbean Sea during the first and last decades of the month. Due to the lack of important cyclonic disturbances, the usual charts have been omitted.

Fog was unusually prevalent north of the 40th parallel and the number of days on which it occurred in different localities was as follows: Over the Grand Banks, from 13 to 15 days; along the American coast between the 40th and 45th parallels, from 5 to 23 days; over the steamer lanes between the 20th and 45th meridians, from 10 to 15 days; along the European coast, from 2 to 6 days.

Barometric data for several island and coast stations are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian)—North Atlantic Ocean, July, 1930*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Belle Isle, Newfoundland	29.83	[1]−0.04	30.10	11th	29.50	22d.
Halifax, Nova Scotia	29.88	[2]−0.07	30.08	5th [3]	29.48	20th.
Nantucket	29.90	[2]−0.08	30.16	16th	29.66	20th.
Hatteras	29.98	[2]−0.06	30.20	5th	29.78	10th.[3]
Key West	30.04	[2] 0.00	30.14	23d [3]	29.94	14th.
New Orleans	30.06	[2]+0.03	30.16	23d [3]	29.90	13th.
Cape Gracias, Nicaragua	29.91	[1] 0.00	29.96	20th [3]	29.84	2d.[3]
Turks Island	30.11	[1]+0.04	30.18	22d [3]	30.02	6th.
Bermuda	30.15	[2]−0.03	30.30	16th	29.98	28th.
Horta, Azores	30.21	[1]−0.06	30.50	7th	29.76	19th.
Lerwick, Shetland Islands	29.77	[1]−0.03	30.03	9th	29.37	18th.
Valencia, Ireland	29.91	[1]−0.07	30.41	10th	29.32	17th.
London	29.86	[1]−0.12	30.24	7th	29.39	18th.

[1] From normals shown on Hydrographic Office Pilot Charts, based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian time.
[2] From normals based on 8 a. m. observations.
[3] And on other dates.

Reports were received indicating that unusually strong easterly and northeasterly trade winds prevailed in the Caribbean Sea on the 1st, 4th, and 6th, occurring on the 4th in the region of the Canal Zone.

Favorable weather was the rule over the greater portion of the ocean during the first decade of the month, except that on the 6th moderate gales prevailed over a limited area in the vicinity of Hatteras and also over the eastern section of the northern steamer lanes, while on the 9th a gale was reported by a vessel about 250 miles east of Belle Isle.

From the 11th to 14th a disturbance was over the 40th parallel between the 55th meridian and American coast that apparently moved but little during that period.

From the 15th to 17th a well developed LOW was over Ireland, and while, according to ship reports, moderate winds prevailed, on the 17th the station at Blacksod, Ireland, reported a northerly wind, force 7. This LOW drifted slowly eastward and from the 21st to 25th remained nearly stationary over the North Sea, accompanied by favorable weather.

From the 18th to 20th moderate gales prevailed over the steamer lanes east of the 25th meridian, while from the 21st to 24th light to moderate winds were the rule over the ocean as a whole.

On the 25th a LOW was central near 53° N., 20° W., that moved slowly eastward, increasing in intensity, and on the 26th moderate to strong gales were reported by vessels between the 20th meridian and the coast of Ireland. This disturbance then decreased in force and extent, although from the 27th to 29th westerly gales prevailed in the southerly quadrants.

On the 31st a well-developed depression was central near 47° N., 25° W., accompanied by winds of force 7 and 8 at time of observation, that increased to force 10 later in the day.

On the 20th, 23d, 29th, and 30th the northeast and easterly trade winds were again unusually strong in the southwestern Caribbean Sea, extending on the 29th to the Canal Zone.

The following reports of waterspouts have been received:

British S. S. *Princess May*, Capt. R. Thompson; observer, W. R. Hunter, Cuba toward Philadelphia.

July 1, 1930, at 12.30 E. S. T., in 34° 01′ N., 75° 15′ W., a violent squall, reaching force 6 and traveling NE., accompanied by a heavy rain, sheet lightning, and thunder. At this time the barometer read 30.06 inches, temperature of air 79° F., of water at surface 79° F. In rear of squall two waterspouts formed and rose about 20 feet in the air. They both lasted for about three minutes and then subsided.

American S. S. *Fred W. Weller*, Capt. S. Purdy; observer, F. Marcus; Corpus Christi toward Boston.

July 27, 6.50 a. m. Observed two incomplete waterspouts to the eastward of American Shoals Lighthouse (24° 20′ N., 81° 40′ W.). Both lasted four minutes, then the upper and lower parts did not join. Twenty minutes later heavy showers of rain from the direction of the waterspouts.

OCEAN GALES AND STORMS, JULY, 1930

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Porto Rico, Am. S. S.	San Juan	New York	39 52 N	73 56 W	July 6	10 p., 6	July 6	29.67	WSW	WSW, 12	WSW	WSW, 12	Steady.
Oranian, Br. S. S.	Avonmouth	Montreal	52 40 N	50 08 W	July 9	8 a., 9	July 9	29.57	S	S, 4	S	S, 8	Do.
Statendam, Du. S. S.	Rotterdam	New York	40 58 N	61 52 W	July 11	5 p., 11	July 11	29.71	SSW	SW, 8	SW	SW, 8	SSW-S.
Induna, Br. S. S.	Huelva	Baltimore	35 02 N	69 50 W	July 8	9 p., 12	July 12	29.93	SW	SW, 8	NW	SW, 8	SW-NW.
Jean Jadot, Belg. S. S.	New York	Antwerp	40 33 N	62 15 W	July 13	4 a., 13	July 13	29.90	SSW	SSW, 6	SSE	—, 10	
California, Fr. S. S.	Havre	New York	41 07 N	61 12 W	July 14	—, 14	July 14	29.68	S	S, 2	SW	—, 8	SSE-S-SW.
Schuylkill, Br. M. S.	Baytown	Liverpool	47 58 N	28 26 W	July 17	3 p., 18	July 20		SSE	SSE, 8	N	—, 9	SSE-E-N.
Schenectady, Am. S. S.	New York	Copenhagen	58 25 N	15 40 W	July 25	10 p., 25	July 26	29.35	SE	SE, 8	SE	SSE, 9	SE-SSE.
Sarcoxie, Am. S. S.	Havre	New York	49 28 N	7 20 W	July 28	4 a., 28	July 29	29.82	WSW	WSW, 4	NW	W, 8	Steady.
Do	do	do	44 42 N	29 20 W	July 31	2 p., 31	Aug. 1	29.73	WSW	W, 9	NNW	W, 10	WSW-W.
Georgia, Dan. S. S.	Norfolk	Rotterdam	47 26 N	26 12 W	July 29	8 a., 31	do	29.51	SW	WNW, 8	NNW	—, 9	WNW-NNW.
NORTH PACIFIC OCEAN													
Kentucky, Am. S. S.	Davao, P. I.	San Francisco	44 16 N	162 21 W	July 4	4 a., 5	July 5	29.96	ENE	ENE, 8	ENE	ENE, 8	Steady.
Pres. Hayes, Am. S. S.	Manila	do	17 23 N	140 24 E	July 7	9 a., 7	July 7	29.88	ESE	ESE, 7	ESE	ESE, 8	Do.
Tecumseh, Br. S. S.	Yokohama	San Pedro	38 36 N	155 07 E	July 10	Noon, 10	July 10	29.29	E	E, —	ESE	ENE, 8	E-ENE.
Triumph, Am. M. S.	Newchwang	Hong Kong	26 50 N	122 10 E	July 13	Mdt., 13	July 14	29.14	E	ESE, 9	SSE	ESE, 9	ESE-S.
Liberator, Am. S. S.	Hong Kong	Honolulu	24 04 N	132 32 E	July 26	Noon, 26	July 26	28.97	NW	W, —	SE	W, 8	W-WSW.
Taiyo Maru, Jap. S. S.	Yokohama	San Francisco	35 06 N	141 45 E	July 29	3 a., 30	July 31	29.75	NE	E, 7	S	SE, 8	ENE-ESE.
SOUTH ATLANTIC OCEAN													
Brasilien, Dan. S. S.	Barry	River Plate	29 00 S	46 58 W	July 14	2 a., 14	July 16	29.84	SW	SW, 8	WSW	WSW, 10	SW-WSW.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

Pressure conditions on the North Pacific Ocean during July, 1930, were more than ordinarily devoid of gradient, and therefore little conducive to the production of rough weather. Over the greater part of the ocean in middle, and even in higher, latitudes anticyclonic conditions prevailed even more completely than in the previous June, when the North Pacific HIGH covered a large and almost unbroken area. In July the Aleutian LOW had practically vanished, and only a few and comparatively unimportant cyclones appeared from time to time in the Bering Sea and in Alaskan waters of the Pacific. Such northern depression as persisted was central considerably to the northward of the Aleutian chain. The departures from the normal barometric pressure, as indicated in the following table, were slightly above in middle and upper latitudes and, as shown by the figures for Honolulu and Midway Island, slightly below in more southern waters.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, at indicated hours, North Pacific Ocean and adjacent waters, July, 1930*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Point Barrow [1] [2]	29.84		30.12	29th	29.50	20th.
Dutch Harbor [1] [3]	30.04	+0.02	30.38	5th	29.74	28th.
St. Paul [1] [4]	29.92	+0.07	30.32	16th	29.50	29th.
Kodiak [1]	29.99	+0.03	30.18	6th	29.66	19th.
Midway Island [1] [5]	30.07	−0.01	30.20	1st	29.94	10th.
Honolulu [6]	29.99	−0.03	30.07	8th	29.89	13th.
Juneau [6]	30.08	+0.03	30.27	17th	29.85	3d.
Tatoosh Island [6] [7]	30.13	+0.06	30.28	30th	29.94	2d.
San Francisco [6] [7]	29.96	+0.01	30.14	29th	29.80	3d.
San Diego [6] [7]	29.90	+0.01	30.05	23d	29.74	12th.

[1] P. m. observations only.
[2] For 24 days.
[3] For 28 days.
[4] For 29 days.
[5] For 30 days.
[6] A. m. and p. m. observations.
[7] Corrected to 24-hour mean.

It is significant that, as deduced from a goodly number of reports, hardly a gale of higher than moderate force occurred along the northern steamship routes. Such a

few higher velocities as were encountered include winds of force 7 met with at points off the California and Washington coasts on the 19th to 21st, a fresh gale that blew on the 5th near 45° N., 160° E., and moderate to fresh gales that occurred near 37° N., 155° E. on the 10th and 11th. In fact, this great region seems to have been quieter this month than during any other similar period or month in many years past.

It was only in Asiatic and adjacent waters that any storm weather of consequence occurred. Reporting steamships encountered moderate gales northwest of Guam on the 7th, about 600 miles east of Taiwan on the 26th, and southeast of Japan on the 30th; also strong southeasterly gales north of Taiwan on the 13th and 14th. all connected with the activities of various typhoons of the month. The report of the American steamer *Liberator* for the 26th showed a fresh west gale in 24° 04′ N., 132° 32′ E., with barometer as low as 28.97 inches.

In absence of other specific reports of these typhoons at this writing, a brief résumé of their movements, drawn from the Tokyo weather charts, will indicate the stormy character of the weather in the Far East.

A moderate typhoon, which appeared in the China Sea on June 30, went up the China coast and died out in southeastern Siberia on July 5.

A typhoon which originated in the neighborhood of Guam on the 4th, touched northern Luzon on the 11th, crossed Taiwan on the 13th, became apparently violent over the Yellow Sea on the 15th, then lost energy as it proceeded northward.

Following this, a storm came from east of Guam on the 9th. It became violent east of Taiwan on the 15th, and by the morning of the 18th was devastating Kiushu, the southwesternmost island of Japan. By night it was over Chosen (Korea) as a heavy storm, but dissipated inland on the following day. According to press reports, the heavy rains and hurricane velocities attending this typhoon caused the loss of approximately 1,000 fishing craft and a general property loss estimated at $50,000,000 in Kiushu. Damage also was extensive over Chosen, while altogether the known loss to life latest reported upon was in excess of 400.

On the 18th another typhoon appeared east of Guam. It went rapidly westward, crossing Luzon on the 22d and entering the China Sea. On the 24th it struck Hong Kong with some force, then disappeared in the continent.

The fifth typhoon appeared at some distance north of Guam on the 24th. It attained great violence on the 26th, crossed northern Taiwan on the 28th, and at the end of July still lay over extreme eastern China, causing strong south and southwest winds in the Taiwan Channel and neighboring waters.

The sixth typhoon formed in the wake of its predecessor and was central near 24° N., 144° E., on the 28th. It moved northward, and on the 31st lay over south-central Japan, apparently of moderate energy only and decreasing in force.

No cyclones occurred in Mexican west coast waters this month, but on the 25th, 30th, and 31st moderate northers of force 6 and 7 were reported by seamen in the Gulf of Tehuantepec. Coincident with this occurrence, trade winds of moderate gale force were experienced in the southwestern part of the Caribbean Sea, caused by anticyclonic conditions which extended southward from the United States. Weather of this brisk type is rather unusual at this season in these waters.

At Honolulu the prevailing wind continued from the east, with the highest velocity at the rate of 24 miles an hour from the same direction on the 28th.

Frequent and extensive fog banks formed north of the fortieth parallel, several trans-Pacific vessels reporting their occurrence for an entire week or more at a stretch, unbroken except for brief intervals. Over a considerable region south of the central Aleutians, and extending thence westward almost to the Japanese coast, fog was met with on at least 40 to 60 per cent of the days of the month. Along the northern routes between the one hundred and eightieth meridian and the longitude of 145° W., the occurrence lessened to 20 to 40 per cent. There were several days with fog in Alaskan waters. Off the coast of the United States from Puget Sound to Point Arguello fog was reported on from 4 to 8 days, and off Lower California on 9 days. In the Yellow Sea, with only a few reports available, fog was noted as encountered on at least 5 days.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, July, 1930

[For description of tables and charts, see January, 1930, REVIEW, p. 37]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	83.7	+3.6	Madison	111	29	Valley Head	50	2	3.96	−1.49	Calera	11.78	Valley Head	0.33
Arizona	80.1	−0.8	Gila Bend	120	2	Bright Angel Ranger Station.	37	3	3.19	+0.97	Spring Valley Ranger Station.	9.58	2 stations	T.
Arkansas	84.7	+4.7	3 stations	115	29	Dutton	42	16	0.74	−3.08	Marshall	3.80	do	0.00
California	72.6	−0.4	Greenland Ranch	122	14	Portola	32	23	0.02	−0.07	Campo	1.12	181 stations	0.00
Colorado	67.7	+1.1	Palisade	106	5	Pearl	24	1	3.34	+0.96	North Lake	8.03	Fruita	T.
Florida	82.4	+1.2	Cottage Hill	108	11	2 stations	63	[1] 2	4.44	−2.75	Perry	11.48	Hypoluxo	1.13
Georgia	82.4	+2.6	2 stations	109	12	Tallapoosa	51	[1] 3	5.72	+0.01	Macon	10.00	Atlanta	1.48
Idaho	69.9	+1.6	do	110	[1] 14	2 stations	28	20	0.36	−0.31	Preston	2.75	15 stations	0.00
Illinois	80.2	+4.2	4 stations	112	28	do	41	15	1.03	−2.27	Morrisonville	2.84	Flora	T.
Indiana	77.4	+2.1	Washington	113	28	do	40	[1] 2	1.78	−1.62	Royal Center	5.46	Princeton	0.19
Iowa	77.9	+4.2	Keokuk No. 2	112	27	do	40	15	1.49	−2.34	Hampton	5.58	Akron	T.
Kansas	81.4	+3.2	3 stations	112	[1] 12	do	48	15	1.99	−1.33	Wakeeney	5.43	Pleasanton	0.17
Kentucky	80.5	+3.7	Greensburg	114	28	do	45	[1] 3	1.25	−2.89	Manchester	5.27	Mayfield	0.00
Louisiana	83.4	+1.8	Plain Dealing	111	29	do	55	[1] 17	3.79	−2.43	New Orleans No. 2	9.19	Plain Dealing	0.00
Maryland-Delaware	77.1	+1.9	Millsboro, Del	110	21	Grantsville, Md	38	[1] 4	1.58	−2.75	Milford, Del	6.01	Keedysville, Md	0.18
Michigan	69.2	+0.5	2 stations	105	[1] 19	Black Lake Forest	29	3	1.38	−1.57	Grayling	3.98	Bad Axe	0.15
Minnesota	71.9	+2.7	do	108	27	Meadowlands	34	14	2.51	−1.01	Waseca	7.61	Ada	0.18
Mississippi	84.5	+3.6	Holly Springs	115	29	Batesville	52	[1] 3	2.56	−2.37	Macon	5.87	Greenville	0.00
Missouri	81.2	+3.9	Mexico	113	28	2 stations	42	[1] 15	0.97	−3.03	Joplin	3.42	2 stations	T.
Montana	69.6	+3.3	Mildred	110	9	Eureka	25	27	1.00	−0.48	Lewistown	2.87	Libby	0.03
Nebraska	78.8	+4.1	2 stations	112	[1] 27	Ewing	40	14	1.50	−1.84	McCook	8.70	3 stations	T.
Nevada	73.1	+0.6	Logandale	115	2	San Jacinto	30	27	0.16	−0.21	San Jacinto	0.86	6 stations	0.00
New England	68.6	−0.4	Springfield, Mass	104	21	Woodstock, Vt	38	16	3.80	+0.07	Hubbardston, Mass	6.68	Hyannis, Mass	1.26
New Jersey	74.3	+0.9	Elizabeth	105	21	2 stations	42	[1] 15	3.98	−0.63	Hightstown	6.45	Belleplain	1.85
New Mexico	70.3	−0.6	2 stations	110	1	Selsor Ranch	32	3	3.56	+0.86	Clovis	8.48	2 stations	0.00
New York	69.3	−0.2	do	103	21	Allegany State Park	33	15	2.97	−0.96	Wanakena	7.12	do	1.22
North Carolina	78.2	+2.1	Caroleen	106	12	Banners Elk	38	3	3.70	−2.24	Southport	9.30	Moxley	0.50
North Dakota	72.3	+4.8	Napoleon	107	11	Wishek	34	14	1.04	−1.57	Hankinson	4.37	Energy	0.02
Ohio	75.6	+2.2	Circleville	109	20	Mt. Vernon	35	15	1.53	−2.30	Peebles	3.46	Cambridge	0.51
Oklahoma	84.0	+2.4	Poteau	112	29	Tahlequah	48	16	1.01	−1.63	Meeker	4.75	2 stations	0.00
Oregon	66.6	0.0	2 stations	109	[1] 11	2 stations	25	19	0.05	−0.39	Wallowa	0.57	50 stations	0.00
Pennsylvania	73.0	+1.1	Phoenixville	106	21	Somerset	33	15	2.23	−2.12	Bethlehem	6.46	Arendtsville	0.17
South Carolina	81.9	+2.1	Calhoun Falls	108	12	Spartanburg	52	17	4.80	−1.07	Yemassee	9.72	Caesars Head	2.06
South Dakota	78.0	+6.1	2 stations	112	[1] 7	Strool	35	20	0.95	−1.86	Custer	5.59	2 stations	0.00
Tennessee	81.7	+4.3	Perryville	113	29	Crossville	44	3	2.36	−2.02	Kingsport	5.76	Memphis	0.14
Texas	84.0	+1.1	Mount Pleasant	111	30	Llano	50	16	1.06	−1.55	Bon Wier	7.70	16 stations	0.00
Utah	72.9	+1.2	St. George	107	15	2 stations	34	[1] 1	1.21	+0.21	Trout Creek Ranger Station.	3.78	Huntsville	0.00
Virginia	78.2	+3.0	Woodstock	109	20	Burkes Garden	40	4	1.77	−2.80	Speers Ferry	4.62	Dale Enterprise	0.08
Washington	66.3	0.0	Wahluke	111	13	Chewelah	29	20	0.07	−0.59	Republic	0.74	29 stations	0.00
West Virginia	74.9	+1.8	Moorefield	109	28	2 stations	34	4	1.90	−2.50	Kayford	7.02	Wardensville	0.06
Wisconsin	71.0	+1.6	Waupaca	105	20	Amery	31	14	2.56	−1.11	Weyerhauser	5.15	Florence	1.18
Wyoming	67.9	+2.2	2 stations	106	[1] 8	Riverside	21	27	1.21	−0.14	Knowles	3.69	Wamsutter	0.10
Alaska (June)	52.1	−0.2	Kake	88	16	Porcupine Creek	24	11	2.18	+0.15	Ketchikan	10.72	Anchorage	0.37
Hawaii	75.0	+0.6	2 stations	94	[1] 6	2 stations	52	[1] 10	6.05	+0.09	Wahiawa Water Company Intake.	43.80	8 stations	0.00
Porto Rico	79.2	+0.4	San German	98	5	Guineo Reservoir	51	16	3.66	−3.09	Coloso	13.40	Juana Diaz (Guayabal).	0.65

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, July, 1930*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							69.3	+0.4										76	2.98	-0.5										5.5		
Eastport	76	67	85	29.78	29.86	-0.07	61.5	+1.1	79	20	70	48	6	53	29	57	55	82	4.76	+1.7	18	4,779	s.	25	sw.	1	5	6	20	7.5	0.0	0.0
Greenville, Me.	1,070	6	----	28.73	29.88	------	64.1	------	86	19	74	45	16	54	35	----	----	----	4.59	------	13	3,560	nw.	----	----	----	8	11	12	----	0.0	0.0
Portland, Me.	103	82	117	29.77	29.89	-.06	68.8	+0.7	90	17	76	56	16	61	31	61	57	71	3.59	+0.4	12	4,864	s.	27	nw.	8	12	12	7	4.5	0.0	0.0
Concord	289	70	79	29.58	29.88	-.08	68.7	+0.2	93	18	80	44	16	58	38	----	----	----	2.47	-1.1	10	3,078	nw.	17	nw.	8	14	6	11	5.2	0.0	0.0
Burlington	403	11	48	29.45	29.87	-.07	67.2	-3.1	87	19	77	47	4	58	29	----	----	----	3.07	-0.4	15	4,804	s.	28	s.	28	7	11	13	6.2	0.0	0.0
Northfield	876	12	60	------	29.90	-.04	64.6	-1.3	87	19	77	40	5	52	38	----	----	78	3.64	+0.1	14	2,808	s.	16	sw.	19	4	18	9	6.2	0.0	0.0
Boston	125	106	165	29.76	29.88	-.08	72.6	+0.9	94	18	81	58	15	65	29	65	60	68	3.36	-0.1	8	4,773	nw.	20	sw.	14	11	9	11	5.4	0.0	0.0
Nantucket	12	14	90	29.88	29.89	-.09	69.6	+1.8	84	27	76	57	29	63	19	65	64	87	2.16	-0.7	8	8,473	sw.	31	sw.	19	9	13	9	5.4	0.0	0.0
Block Island	26	11	46	29.87	29.90	-.07	70.4	+2.0	85	21	77	58	15	64	19	66	64	84	1.78	-1.3	9	8,365	sw.	26	sw.	19	10	12	9	5.2	0.0	0.0
Providence	160	215	251	29.72	29.89	-.08	72.9	-0.5	93	19	82	56	15	64	26	65	60	67	3.80	+0.5	8	6,478	nw.	33	se.	27	13	9	9	4.9	0.0	0.0
Hartford	159	122	----	29.73	29.90	-.07	72.9	+1.3	99	21	83	53	16	63	35	----	----	----	2.55	-1.8	11	------	n.	----	----	----	12	11	8	4.8	0.0	0.0
New Haven	106	74	153	29.79	29.90	-.07	73.4	+1.6	100	21	82	53	16	64	31	66	63	72	1.65	-2.7	9	5,012	s.	31	nw.	9	14	10	7	4.7	0.0	0.0
Middle Atlantic States							76.4	+1.5										68	2.88	-1.4										4.8		
Albany	97	107	115	29.80	29.90	-.06	72.8	+0.2	101	21	83	54	15	63	37	66	62	74	4.33	+0.9	10	4,238	s.	24	nw.	6	16	11	4	3.7	0.0	0.0
Binghamton	871	10	84	29.02	29.93	-.04	69.8	-0.2	98	21	81	48	15	58	36	----	----	----	2.35	-1.4	11	3,273	nw.	18	sw.	13	6	15	10	5.7	0.0	0.0
New York	314	414	454	29.59	29.92	-.06	75.0	+1.2	99	21	83	56	15	67	23	66	62	70	5.05	+0.8	10	8,310	nw.	36	nw.	3	6	15	10	6.1	0.0	0.0
Bellefonte	1,050	5	36	28.86	29.94	------	70.1	------	97	26	85	40	15	55	41	63	58	69	1.41	------	8	------	sw.	----	----	----	9	18	4	4.6	0.0	0.0
Harrisburg	374	94	104	29.55	29.94	-.04	77.0	+2.2	100	21	88	55	16	66	31	66	59	58	1.24	-2.6	7	3,823	nw.	19	w.	21	13	13	5	4.4	0.0	0.0
Philadelphia	114	123	367	29.83	29.95	-.03	78.0	+1.8	103	21	87	58	15	69	25	68	63	64	4.06	-0.1	12	7,582	sw.	44	nw.	6	6	14	11	5.8	0.0	0.0
Reading	325	81	98	29.59	29.93	------	76.6	+1.1	101	21	88	54	15	66	30	66	60	60	1.73	-2.5	9	3,567	n.	22	sw.	22	10	14	7	5.0	0.0	0.0
Scranton	805	111	119	29.10	29.94	-.04	71.2	-0.5	99	21	83	48	16	60	36	63	58	66	2.78	-1.2	7	4,127	n.	24	nw.	1	10	17	4	4.3	0.0	0.0
Atlantic City	52	37	172	29.87	29.92	-.06	74.6	+2.5	102	21	82	57	15	68	27	69	66	78	4.19	+0.3	10	9,261	s.	48	n.	9	12	13	6	4.6	0.0	0.0
Cape May	17	13	49	------	------	------	74.8	+1.4	100	21	83	58	15	67	28	69	67	81	2.77	-1.0	10	------	s.	----	----	----	12	12	7	----	0.0	0.0
Sandy Hook	22	10	55	29.88	29.90	------	74.6	------	96	21	82	60	15	67	23	68	65	76	3.94	-1.2	9	7,366	w.	44	nw.	22	10	11	10	4.6	0.0	0.0
Trenton	190	159	183	29.72	29.92	------	75.6	+1.1	101	21	86	56	15	66	27	67	63	69	3.94	0.0	12	5,574	sw.	47	nw.	22	10	10	11	5.7	0.0	0.0
Baltimore	123	100	215	29.80	29.92	-.06	80.6	+3.4	104	21	90	60	15	71	27	69	63	57	0.64	-4.0	7	6,404	sw.	31	sw.	22	11	14	6	4.9	0.0	0.0
Washington	112	62	85	29.82	29.93	-.07	80.4	+3.6	106	20	92	56	15	69	30	68	63	61	2.30	-2.4	8	3,418	sw.	20	nw.	29	14	13	4	4.3	0.0	0.0
Cape Henry	18	8	54	29.92	29.95	------	78.6	+1.1	102	21	86	64	11	71	26	72	70	77	2.03	-3.3	9	6,458	sw.	39	ne.	12	13	13	5	4.5	0.0	0.0
Lynchburg	681	153	188	29.24	29.97	-.04	80.5	+3.0	102	20	92	57	4	69	31	68	62	57	0.90	-3.3	6	3,970	w.	40	ne.	29	14	15	2	3.8	0.0	0.0
Norfolk	91	170	205	29.87	29.96	-.04	79.8	+1.1	98	21	88	66	15	72	24	71	68	73	2.50	-3.2	10	7,379	s.	50	nw.	6	12	11	8	4.9	0.0	0.0
Richmond	144	11	52	29.81	29.95	-.06	79.8	+1.3	103	22	90	61	15	69	31	70	66	72	4.51	-0.2	7	4,627	sw.	28	w.	29	14	13	4	4.0	0.0	0.0
Wytheville	2,304	49	55	27.68	29.96	-.05	73.2	+0.6	95	28	86	52	15	61	37	64	58	63	2.66	-1.3	7	3,616	w.	23	w.	22	13	12	6	4.7	0.0	0.0
South Atlantic States							81.4	+2.3										74	4.83	-1.0										5.2		
Asheville	2,253	70	84	27.73	30.00	-.02	74.5	+2.8	96	29	86	56	4	63	30	65	61	70	1.12	-3.2	12	3,909	n.	28	n.	27	13	14	4	4.5	0.0	0.0
Charlotte	779	55	62	29.17	29.98	-.04	81.6	+3.2	102	12	92	62	15	71	28	70	66	66	2.84	-2.3	8	2,578	sw.	14	ne.	23	9	15	7	5.4	0.0	0.0
Greensboro	886	5	56	29.05	29.99	------	79.0	------	99	29	91	59	15	67	32	70	66	71	3.42	------	11	4,533	sw.	28	n.	28	8	17	6	5.2	0.0	0.0
Hatteras	11	5	50	29.96	29.97	-.04	79.4	+1.2	91	30	85	67	13	73	19	75	73	83	3.91	-1.6	11	7,397	sw.	48	nw.	24	17	9	5	3.6	0.0	0.0
Raleigh	376	103	110	29.58	29.96	-.06	80.4	+1.6	99	22	90	62	15	71	25	72	68	72	5.94	+0.5	9	4,751	sw.	43	nw.	31	7	13	11	5.7	0.0	0.0
Wilmington	78	81	91	29.91	29.99	-.02	81.6	+2.5	98	30	90	65	16	73	25	75	73	82	7.48	+0.4	20	4,316	sw.	24	s.	14	8	15	8	5.5	0.0	0.0
Charleston	48	11	92	29.95	30.00	-.03	83.9	+2.5	99	8	92	71	11	76	26	76	74	78	6.09	-0.8	11	6,237	sw.	41	ne.	25	8	17	6	5.2	0.0	0.0
Columbia, S. C.	351	41	57	29.61	29.98	-.04	82.4	+1.5	104	12	93	65	16	72	31	73	69	73	6.47	+1.1	14	3,659	sw.	25	nw.	13	7	15	9	5.6	0.0	0.0
Due West	711	10	55	29.26	30.02	------	81.4	------	105	12	93	62	3	70	34	----	----	----	6.47	------	11	4,729	sw.	28	ne.	28	8	15	8	5.5	0.0	0.0
Greenville, S. C.	1,039	139	146	28.92	29.98	------	81.0	+4.1	102	28	91	60	15	71	30	70	66	66	3.76	-1.6	9	4,648	w.	32	sw.	31	9	15	7	5.3	0.0	0.0
Augusta	182	62	77	29.78	29.97	-.05	83.9	+2.6	104	12	95	67	15	73	30	74	70	70	4.37	-1.0	12	3,194	s.	34	ne.	30	8	16	7	5.5	0.0	0.0
Savannah	65	150	194	29.93	30.00	-.03	83.6	+2.1	100	23	93	69	3	74	25	75	73	78	6.39	-0.2	9	6,827	sw.	33	n.	30	7	16	8	5.3	0.0	0.0
Jacksonville	43	209	245	29.98	30.03	.00	82.8	+0.7	96	23	91	70	11	74	23	75	72	77	4.74	-2.0	10	6,699	s.	33	s.	11	10	14	7	5.2	0.0	0.0
Florida Peninsula							83.0	+1.1										75	3.23	-2.3										4.8		
Key West	22	10	64	30.02	30.04	+.01	83.1	-0.4	91	14	88	70	19	78	19	76	74	73	2.53	-0.8	11	4,992	se.	20	se.	18	13	15	3	4.3	0.0	0.0
Miami	25	124	168	30.04	30.07	+.02	82.6	+1.6	89	29	88	70	8	78	16	76	73	74	3.58	-1.8	11	5,040	se.	21	sw.	29	5	22	4	5.5	0.0	0.0
Tampa	35	79	197	30.02	30.05	+.01	83.3	+2.1	94	23	91	71	19	76	21	75	73	77	3.58	-4.4	14	5,010	w.	34	n.	26	3	20	8	6.0	0.0	0.0
Titusville	44	5	----	30.01	30.06	------	85.0	------	100	24	96	68	1	74	26	----	----	----	2.75	------	5	------	se.	----	----	----	19	10	2	3.6	0.0	0.0
East Gulf States							83.0	+2.3										72	4.05	-1.7										4.7		
Atlanta	1,173	190	216	28.80	30.00	-.02	81.3	+3.2	103	12	91	64	16	71	30	69	64	64	1.48	-3.2	8	5,310	nw.	29	w.	14	9	16	6	5.3	0.0	0.0
Macon	370	78	87	29.61	30.00	-.02	82.2	+1.0	104	12	93	65	3	72	30	72	69	72	10.00	+5.3	14	3,580	s.	29	ne.	25	12	12	7	5.0	0.0	0.0
Thomasville	273	49	103	29.74	30.03	.00	81.9	+0.1	102	11	92	68	4	72	30	74	72	83	5.94	-0.8	14	4,073	sw.	25	sw.	15	9	11	11	5.7	0.0	0.0
Apalachicola	36	11	51	29.99	30.03	------	82.4	------	93	23	89	69	11	76	23	77	75	77	5.28	-2.5	10	4,410	sw.	56	n.	11	12	14	5	4.6	0.0	0.0
Pensacola	56	149	185	29.98	30.04	+.3	81.6	+0.6	98	11	87	68	1	76	20	75	73	78	2.91	-3.9	9	7,236	w.	40	ne.	28	4	18	9	5.9	0.0	0.0
Anniston	741	9	57	29.26	30.04	+.2	82.2	+4.3	105	12	96	57	3	69	37	----	----	----	3.45	-1.7	13	2,254	nw.	20	nw.	13	17	13	1	3.5	0.0	0.0
Birmingham	700	11	48	29.27	30.02	+.1	83.9	+3.7	107	29	96	62	3	72	36	71	66	65	3.58	-1.6	6	3,176	s.	28	n.	29	14	16	1	3.8	0.0	0.0
Mobile	57	125	161	29.97	30.03	+.2	83.9	+2.5	103	11	92	68	1	75	23	75	73	77	3.34	-3.6	11	5,170	sw.	31	e.	30	11	12	8	4.8	0.0	0.0
Montgomery	223	100	112	29.77	30.01	-.1	84.6	+2.9	105	13	96	67	3	74	32	73	69	68	2.67	-2.2	9	3,973	sw.	31	ne.	11	11	14	6	4.6	0.0	0.0
Corinth	469	6	----	------	------	------	85.4	------	111	29	101	58	3	70	38	----	----	----	1.38	------	5	------	sw.	----	----	----	11	20	0	----	0.0	0.0
Meridian	375	87	95	29.62	30.00	-.3	83.6	+3.2	105	13	95	65	16	72	29	72	68	66	3.15	-1.7	7	3,137	sw.	24	se.	28	8	18	5	4.8	0.0	0.0
Vicksburg	247	65	73	29.76	30.03	+.3	84.4	+3.1	102	12	94	67	16	74	25	73	69	68	0.68	-3.8	2	3,438	w.	22	se.	8	17	13	1	3.7	0.0	0.0
New Orleans	53	76	84	29.99	30.04	+.4	83.4	+1.0	99	11	92	67	1	75	27	75	72	74	6.11	-0.3	12	3,087	sw.	20	ne.	21	9	15	7	5.0	0.0	0.0
West Gulf States							84.4	+1.8										65	0.90	-2.1										3.4		
Shreveport	249	77	93	29.74	30.00	+.02	86.9	+3.7	105	29	98	68	2	76	28	73	67	59	0.21	-3.4	3	3,675	sw.	19	s.	3	22	9	0	2.7	0.0	0.0
Bentonville	1,303	11	44	28.65	29.98	+.01	80.4	+1.9	103	28	94	49	16	67	41	----	----	----	2.00	------	3	2,721	sw.	15	sw.	16	29	2	0	----	0.0	0.0
Fort Smith	457	79	94	29.51	29.97	.00	85.9	+4.4	108	29	98	61	16	74	30	71	65	54	1.19	-2.2	4	3,748	sw.	24	sw.	1	13	14	4	3.6	0.0	0.0
Little Rock	357	136	153	29.62	29.99	.00	86.4	+5.5	108	29	98	65	16	75	27	69	61	47	0.01	-3.5	1	5,088	sw.	20	n.	14	17	12	2	3.3	0.0	0.0
Austin	605	136	148	29.37	30.00	------	84.4	+0.4	103	31	95	69	10	74	27	72	67	64	0.24	-2.1	2	4,771	s.	26	ne.	31	15	14	2	3.7	0.0	0.0
Brownsville	57	83	100	29.93	29.99	------	83.3	-0.3	95	16	91	72	8	76	19	75	73	78	0.42	-1.5	7	6,026	se.	20	se.	5	15	14	2	3.7	0.0	0.0
Corpus Christi	20	11	78	29.99	30.01	+.05	83.3	+0.6	97	15	89	74	8	77	20	77	75	80	1.29	-0.2	5	6,632	se.	22	se.	25	15	14	2	4.2	0.0	0.0
Dallas	512	220	227	29.46	30.00	------	86.0	------	103	13	96	66	16	76	27	----	----	----	0.01	-2.8	1	7,269	se.	30	s.	6	29	2	0	1.1	0.0	0.0
Fort Worth	670	106	114	29.28	29.97	+.01	86.5	+2.9	106	13	98	68	16	75	30	71	64	53	0.37	-2.2	2	6,161	s.	32	s.	6	16	11	4	3.7	0.0	0.0
Galveston	54	106	114	29.99	30.05	+.07	83.2	-0.2	95	31	88	73	31	78	22	76	74	77	0.31	-3.4	5	5,906	s.	33	nw.	31	14	12	5	4.4	0.0	0.0
Groesbeck	461	11	56	29.54	30.01	------	84.4	------	102	30	96	68	16	73	30	----	----	----	0.26	-1.7	2	5,970	s.	34	se.	22	20	10	1	2.7	0.0	0.0
Houston	138	292	314	29.88	30.02	------	84.4	+0.7	101	13	94	72	3	75	26	----	----	----	2.81	-1.2	7	5,992	se.	35	nw.	14	10	18	3	4.3	0.0	0.0
Palestine	510	64	72	29.99	30.01	+.04	84.4	+2.2	102	13	95	67	2	74	27	72	68	65	0.74	-1.9	4	3,919	s.	27	s.	29	19	11	1	3.2	0.0	0.0
Port Arthur	34	58	66	29.99	30.03	------	83.6	------	98	13	92	68	4	76	22	76	74	78	2.82	-4.1	6	4,210	s.	29	e.	1	17	8	6	3.7	0.0	0.0
San Antonio	693	242	301	29.28	29.99	+.04	84.2	+0.4	99	31	95	69	9	74	26	72	67	64	1.99	-0.2	3	6,885	se.	41	se.	8	11	18	2	4.2	0.0	0.0
Taylor	571	38	51	29.44	30.04	+.08	84.4	+1.7	102	31	96	67	10	73	30	----	----	----	0.80	-1.4	3	4,953	s.	25	se.	22	21	10	0	2.7	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, July, 1930*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							79.2	+2.8										54	1.57	-2.2										3.6		
Chattanooga	762	190	215	29.19	29.98	-0.04	82.0	+3.6	104	12	93	60	3	71	34	69	63	60	1.40	-2.8	8	4,923	sw.	31	sw.	13	6	22	3	4.8	0.0	0.0
Knoxville	995	102	111	28.97	29.99	-.03	80.6	+3.5	104	12	92	59	3	69	33	68	63	61	1.86	-2.5	8	3,465	sw.	24	nw.	27	11	17	3	4.4	0.0	0.0
Memphis	399	76	97	29.57	29.98	-.02	85.4	+4.7	106	12	95	61	3	76	28	70	63	52	0.14	-3.0	1	4,914	sw.	20	ne.	13	20	8	3	3.1	0.0	0.0
Nashville	546	168	191	29.44	30.01	.00	83.4	+4.3	106	28	95	59	3	72	34	68	61	52	1.22	-2.7	6	5,047	w.	40	sw.	13	19	11	1	2.8	0.0	0.0
Lexington	989	193	230	28.98	30.01	.00	79.6	+3.7	104	28	90	54	15	69	29	......	......	......	0.45	-3.2	5	7,425	sw.	27	e.	26	21	9	1	2.6	0.0	0.0
Louisville	525	188	234	29.43	30.00	.00	81.4	+2.8	107	28	92	55	2	70	31	67	59	50	0.25	-3.4	3	6,076	n.	38	nw.	28	15	14	2	3.5	0.0	0.0
Evansville	431	76	116	29.53	29.99	-.01	82.2	+3.5	107	28	94	58	2	71	31	68	59	51	1.23	-2.2	6	4,899	sw.	34	w.	6	14	13	4	4.1	0.0	0.0
Indianapolis	822	194	230	29.12	29.98	-.01	78.0	+2.3	101	28	89	53	2	67	30	64	56	50	0.90	-2.4	9	6,197	sw.	32	n.	26	16	13	2	3.5	0.0	0.0
Royal Center	736	11	55	29.22	30.00	......	73.4	......	100	19	86	46	2	61	34	......	......	......	5.46	+1.7	9	5,282	n.	30	w.	12	16	12	3	4.0	0.0	0.0
Terre Haute	575	96	129	29.38	29.98	......	79.6	......	106	28	92	53	2	68	33	66	59	53	1.25	-1.9	3	5,037	n.	23	n.	13	17	11	3	3.4	0.0	0.0
Cincinnati	627	11	51	29.33	29.99	-.01	78.8	+3.7	103	28	92	52	15	66	36	65	56	51	2.46	-0.8	6	4,060	sw.	25	nw.	26	17	12	2	3.5	0.0	0.0
Columbus	822	216	230	29.12	29.97	-.03	77.0	+2.1	101	20	88	49	15	66	32	64	55	51	1.28	-2.3	6	6,209	sw.	41	nw.	9	16	14	1	3.5	0.0	0.0
Dayton	899	137	173	29.05	29.98	......	77.6	+2.2	101	20	89	51	15	66	34	64	56	52	1.57	-1.7	6	4,796	n.	29	nw.	26	17	14	0	3.3	0.0	0.0
Elkins	1,947	59	67	......	29.98	-.03	70.0	-0.3	94	20	83	43	4	57	39			70	3.01	-2.4	7	2,623	nw.	24	nw.	22	12	11	8	......	0.0	0.0
Parkersburg	637	77	82	29.35	30.00	-.01	78.4	+3.0	104	28	91	52	4	66	38	64	56	50	1.24	-3.0	7	3,327	sw.	21	nw.	22	17	8	6	3.8	0.0	0.0
Pittsburgh	842	353	410	29.09	29.97	-.03	75.0	+0.4	99	20	86	51	15	64	34	64	57	59	1.33	-2.7	6	5,806	nw.	29	nw.	22	15	10	6	4.2	0.0	0.0
Lower Lake Region							71.8	+0.4										63	1.75	-1.5										4.3		
Buffalo	767	247	280	29.12	29.93	-.04	68.8	-1.0	88	26																						
Canton	448	10	61	29.42	29.88	......	67.1	-3.4	88	28	76	51	3	62	20	63	60	73	2.02	-1.0	9	8,174	sw.	39	w.	13	10	15	6	4.5	0.0	0.0
Ithaca	836	5	100	29.05	29.93	......	68.5	-2.0	97	21	78	42	15	57	31	......	......	......	3.54	0.0	9	4,509	sw.	35	sw.	26	8	13	10	5.7	0.0	0.0
Oswego	335	76	91	29.55	29.91	-.05	68.6	-1.8	93	28	80	43	16	57	37	62	59	73	3.75	+0.2	10	4,787	nw.	28	se.	13	9	16	6	5.1	0.0	0.0
Rochester	523	86	102	29.38	29.94	-.03	71.4	+0.7	95	26	76	52	15	61	30	62	57	68	2.11	-0.8	10	4,756	w.	18	nw.	14	14	8	9	4.5	0.0	0.0
Syracuse	596	65	79	29.28	29.92	-.05	71.6	+0.8	95	21	81	51	15	61	31	62	56	62	2.15	-0.8	7	4,828	nw.	24	nw.	9	14	13	4	4.3	0.0	0.0
Erie	714	130	166	29.20	29.95	-.03	72.0	+1.0	95	26	81	49	15	62	31	......	......	......	1.67	-2.0	9	4,222	s.	19	sw.	21	10	11	10	5.1	0.0	0.0
Cleveland	762	267	337	29.16	29.96	-.03	73.6	+2.2	98	20	80	51	15	64	27	64	59	66	0.83	-2.2	4	6,931	nw.	36	sw.	21	19	9	3	3.3	0.0	0.0
Sandusky	629	5	67	29.31	29.98	-.01	75.2	+1.8	102	19	82	55	15	66	27	63	57	58	0.74	-2.7	5	7,585	n.	33	nw.	28	11	12	8	4.4	0.0	0.0
Toledo	628	208	243	29.30	29.97	-.02	75.5	+2.3	102	20	86	51	4	64	35	......	......	......	1.34	-2.1	5	4,641	sw.	27	w.	26	10	17	4	4.3	0.0	0.0
Fort Wayne	856	100	119	29.08	29.98	......	75.0	+1.5	101	19	86	52	15	65	30	63	55	53	0.68	-2.3	5	7,509	sw.	33	sw.	19	17	13	1	3.0	0.0	0.0
Detroit	730	218	258	29.20	29.97	-.01	74.6	+2.5	100	28	87	51	2	63	32	64	57	56	1.71	-1.9	6	5,455	sw.	35	s.	21	13	16	2	3.7	0.0	0.0
											85	53	4	64	28	63	56	57	0.50	-2.8	4	5,824	sw.	26	sw.	18	12	14	5	4.2	0.0	0.0
Upper Lake Region							68.7	+0.8										68	1.54	-1.5										4.1		
Alpena	609	13	92	29.30	29.96	-.01	66.0	+0.1	90	28	76	45	4	56	23	60	56	69	1.16	-1.6	9	6,667	nw.	40	se.	12	15	11	5	4.3	0.0	0.0
Escanaba	612	54	60	29.30	29.95	-.02	65.8	-0.2	84	10	75	44	14	57	27	60	56	72	1.83	-1.5	11	6,069	s.	31	n.	27	12	15	4	4.5	0.0	0.0
Grand Haven	632	54	89	29.28	29.95	-.03	68.9	+0.2	90	12	77	48	14	60	27	61	56	64	0.82	-1.8	6	6,752	sw.	40	w.	12	16	7	8	4.1	0.0	0.0
Grand Rapids	707	70	87	29.22	29.97	-.01	73.6	+1.3	99	20	85	50	2	62	33	62	54	55	0.56	-2.4	5	6,972	sw.	35	sw.	20	13	10	8	4.6	0.0	0.0
Houghton	668	64	99	29.22	29.93	-.03	65.4	-0.1	93	27	75	46	12	56	34	......	......	......	2.17	-0.9	5	6,489	w.	27	w.	29	14	9	8	4.6	0.0	0.0
Lansing	878	6	49	29.04	29.96	......	71.3	+0.4	99	20	84	45	15	58	34	63	58	65	0.50	-2.6	5	2,263	w.	15	w.	24	17	11	3	3.5	0.0	0.0
Ludington	637	60	66	29.27	29.96	......	66.4	+0.2	87	12	74	46	15	58	27	61	57	73	1.50	-1.5	7	5,877	s.	27	n.	13	19	11	1	2.8	0.0	0.0
Marquette	734	77	111	29.16	29.95	-.01	65.4	+0.5	90	27	74	46	13	57	31	60	57	77	1.41	-1.7	6	5,636	w.	40	sw.	16	8	15	8	5.4	0.0	0.0
Port Huron	638	70	120	29.28	29.96	-.02	70.4	+1.6	99	28	81	45	15	60	30	62	58	67	0.27	-2.5	6	6,234	ne.	26	n.	28	13	15	3	4.0	0.0	0.0
Sault Sainte Marie	614	11	52	29.27	29.95	-.02	62.9	-0.9	91	27	73	44	2	53	31	58	54	75	3.67	+0.8	8	4,736	nw.	46	nw.	20	22	6	3	2.4	0.0	0.0
Chicago	673	7	131	29.27	29.99	+.01	74.2	+1.7	101	19	83	54	2	65	30	64	59	64	2.63	-0.7	9	5,866	ne.	29	ne.	28	14	12	5	3.7	0.0	0.0
Green Bay	617	109	141	29.29	29.94	-.03	71.7	+1.7	94	12	83	47	14	61	30	63	58	65	2.15	-1.3	10	6,329	s.	33	w.	27	9	13	9	5.4	0.0	0.0
Milwaukee	681	125	221	29.24	29.97	.00	72.8	+2.7	100	20	82	49	14	63	33	63	57	61	1.33	-1.5	10	7,430	w.	36	w.	12	19	5	7	3.5	0.0	0.0
Duluth	1,133	5	47	28.75	29.95	.00	66.5	+2.6	92	26	77	46	14	56	31	60	56	73	1.57	-2.2	10	6,850	nw.	33	nw.	28	14	11	6	4.2	0.0	0.0
North Dakota							73.1	+4.6										58	1.12	-1.5										3.4		
Moorhead	940	50	58	28.92	29.90	-.04	73.6	+5.5	100	25	87	45	14	61	41	63	57	60	0.48	-3.0	8	4,785	s.	45	nw.	26	16	8	7	3.9	0.0	0.0
Bismarck	1,674	8	57	28.16	29.89	-.04	74.8	+5.0	102	10	89	49	30	60	43	62	54	55	1.90	-0.3	8	5,312	e.	36	nw.	7	22	7	2	2.5	0.0	0.0
Devils Lake	1,478	11	44	28.38	29.92	-.01	71.0	+3.6	98	15	85	46	30	57	46	62	56	65	0.67	-1.9	7	4,953	se.	24	ne.	18	12	14	5	4.0	0.0	0.0
Ellendale	1,457	10	56	28.40	29.92	......	73.2	......	102	11	88	43	1	59	44	......	......	......	1.99	-1.2	4	7,366	se.	43	nw.	7	16	11	4	3.6	0.0	0.0
Grand Forks	833	12	67	......	......	......	71.6	......	99	8	86	44	30	57	42	64	......	......	1.75	......	7	......	nw.	29	nw.	25	20	11	0	......	0.0	0.0
Williston	1,878	41	48	27.97	29.90	-.02	73.0	+4.1	100	15	87	47	29	59	44	60	50	50	0.56	-1.3	10	4,373	ne.	32	nw.	26	19	10	2	3.0	0.0	0.0
Upper Mississippi Valley							78.0	+3.0										58	1.20	-2.3										3.8		
Minneapolis	918	102	208	28.96	29.92	......	75.3	+3.0	98	10	86	50	14	65	30	......	......	......	0.92	-2.8	7	6,504	s.	48	n.	25	14	10	7	4.4	0.0	0.0
St. Paul	837	236	261	29.04	29.92	-.03	74.4	+2.3	96	27	86	51	14	63	30	......	......	......	1.00	-2.6	6	6,504	se.	48	nw.	25	13	13	5	4.3	0.0	0.0
La Crosse	714	11	48	29.18	29.93	-.03	74.4	+1.6	100	20	86	49	15	62	32	66	62	70	3.05	-0.8	7	2,552	s.	14	s.	17	16	12	3	3.8	0.0	0.0
Madison	974	70	78	28.95	29.97	.00	72.8	+0.7	97	20	82	51	14	63	31	64	59	63	2.84	-1.0	7	4,601	sw.	30	nw.	27	17	7	7	3.9	0.0	0.0
Wausau	1,247	4	62	28.66	29.97	......	71.4	......	96	20	84	45	14	59	31	......	......	......	1.96	-2.3	8	3,555	n.	40	nw.	27	16	10	5	4.6	0.0	0.0
Charles City	1,015	10	51	28.91	29.96	.00	75.0	+2.7	99	10	87	49	15	63	37	66	61	65	1.13	-2.6	7	3,493	se.	22	s.	17	18	10	3	3.2	0.0	0.0
Davenport	606	71	79	29.32	29.97	.00	78.6	+3.3	105	27	89	56	14	68	30	67	60	57	1.94	-1.4	6	4,752	sw.	30	sw.	4	15	10	6	4.1	0.0	0.0
Des Moines	861	5	99	29.06	29.94	-.02	80.4	+5.0	106	27	92	50	15	69	34	67	59	52	0.56	-2.9	3	5,844	sw.	33	nw.	4	14	14	3	4.0	0.0	0.0
Dubuque	700	81	96	29.23	29.96	-.01	76.0	+1.9	99	20	86	51	15	66	30	66	60	62	0.94	-3.0	7	3,792	s.	20	n.	27	18	4	9	3.9	0.0	0.0
Keokuk	614	64	78	29.33	29.99	+.01	80.5	+3.6	107	27	91	55	15	70	31	67	60	53	0.30	-3.1	4	4,017	sw.	21	se.	5	14	13	4	4.0	0.0	0.0
Cairo	358	87	93	29.61	29.98	-.02	83.2	+3.6	106	28	94	60	16	72	28	70	64	56	0.04	-3.0	2	4,571	s.	29	ne.	10	14	13	4	4.0	0.0	0.0
Peoria	609	11	45	29.34	30.00	+.02	78.2	+2.8	107	27	91	47	15	65	36	66	59	58	1.02	-2.6	6	3,018	s.	22	ne.	6	21	7	3	2.4	0.0	0.0
Springfield, Ill	636	154	191	29.32	29.98	.00	79.4	+2.9	104	28	90	52	15	68	32	68	62	58	1.33	-1.5	7	6,932	sw.	37	ne.	6	12	17	2	4.0	0.0	0.0
Hannibal	534	74	109	29.43	29.99	+.01	80.5	+3.7	106	27	92	50	15	69	38	......	......	......	0.76	-2.3	2	4,657	sw.	21	e.	6	16	12	3	3.3	0.0	0.0
St. Louis	568	265	303	29.39	29.98	-.01	83.6	+5.0	108	28	94	57	15	73	29	68	60	49	0.25	-2.7	3	6,619	w.	27	sw.	20	19	12	0	2.5	0.0	0.0
Missouri Valley							81.0	+5.2										50	1.05	-2.5										3.1		
Columbia, Mo	784	6	84	29.18	29.99	+.01	81.1	+4.2	108	28	94	51	15	69	38	......	......	......	0.50	-3.0	4	4,356	sw.	19	sw.	21	15	10	6	3.6	0.0	0.0
Kansas City	963	161	181	28.97	29.97	.00	82.8	+4.7	104	27	93	50	15	72	31	67	58	48	1.39	-2.7	6	6,280	s.	30	n.	6	20	7	4	2.8	0.0	0.0
St. Joseph	967	11	49	28.96	29.95	......	81.5	......	106	27	93	5	15	70	32	67	60	53	1.46	-2.2	5	4,497	sw.	31	nw.	6	21	7	3	2.6	0.0	0.0
Springfield, Mo	1,324	98	104	28.66	30.03	+.5	80.2	+3.4	100	28	91	5	15	70	30	66	59	52	0.62	-3.6	4	5,292	sw.	22	n.	13	26	5	0	1.1	0.0	0.0
Iola	984	11	50	28.96	29.98	+.1	81.8	+3.6	106	28	95	53	15	69	37	......	......	......	0.45	-3.3	7	3,564	s.	17	ne.	29	20	4	7	3.1	0.0	0.0
Topeka	987	92	107	......	......	......	82.4	+4.6	104	27	94	54	15	71	34	......	......	......	1.57	-2.7	7	6,035	sw.	26	ne.	28	21	7	3	2.5	0.0	0.0
Lincoln	1,189	11	81	28.70	29.92	-.03	82.8	+6.3	108	27	95	52	1	70	35	67	58	48	1.06	-2.8	6	6,149	s.	32	w.	20	13	13	5	4.2	0.0	0.0
Omaha	1,105	115	122	28.79	29.94	-.01	83.0	+6.3	109	27	94	56	14	72	31	67	58	48	1.03	-2.5	7	4,349	s.	20	n.	28	24	6	1	2.3	0.0	0.0
Valentine	2,598	47	54	27.29	29.94	+.01	77.2	+3.5	104	7	92	48	1	63	40	63	55	52	2.90	-0.1	5	5,322	s.	36	w.	11	14	14	3	3.9	0.0	0.0
Sioux City	1,135	94	164	28.76	29.93	-.02	80.5	+6.2	104	27	92	50	1	69	32	66	59	52	0.72	-2.8	2	6,458	s.	29	s.	2	16	9	6	3.9	0.0	0.0
Huron	1,306	59	74	28.56	29.91	-.03	78.1	+6.3	106	11	93	45	14	63	41	64	55	50	1.15	-2.0	6	5,564	s.	32	w.	26	18	11	2	3.5	0.0	0.0
Pierre	1,572	70	75	28.26	29.88	-.05	81.3	+6.0	109	16	96	52	1	67	40	64	53	46	0.69	-2.0	5	5,531	e.	31	se.	24	21	8	2	2.9	0.0	0.0
Yankton	1,233	49	57	28.64	29.92	-.02	81.4	+7.2	109	27	94	48	1	69	35	......	......	......	0.16	-3.2	3	4,002	sw.	19	se.	2	12	18	1	3.6	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, July, 1930*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation: Thermometer above ground	Elevation: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Northern Slope							**71.8**	**+3.9**										**49**	**0.99**	**−0.6**										**4.0**		
Billings	3,140	5	----				71.9	----	105	6	91	44	20	53	50				1.20		4	----	nw.				9	16	6	----	0.0	0.0
Havre	2,505	11	44	27.36	29.93	+0.02	73.6	+5.3	104	8	89	44	28	58	47	57	44	43	0.76	−1.1	5	3,819	e.	26	sw.	19	17	12	2	3.5	0.0	0.0
Helena	4,124	89	113	25.84	29.94	+.01	70.5	+4.8	96	8	84	49	27	57	37	53	41	40	0.69	−0.4	6	5,069	sw.	36	s.	8	8	14	9	5.2	0.0	0.0
Kalispell	2,973	48	56	26.95	29.94	+.01	67.5	+3.4	97	14	82	41	27	53	42	54	44	50	1.02	−0.1	5	3,891	nw.	25	sw.	9	13	13	5	4.1	0.0	0.0
Miles City	2,371	48	55	27.46	29.94	+.02	77.6	+4.7	107	9	92	52	21	64	39	60	50	45	1.09	−0.4	5	3,402	ne.	30	w.	19	17	13	1	3.3	0.0	0.0
Rapid City	3,259	50	58	26.64	29.96	+.03	75.9	+4.9	101	10	90	52	1	62	39	59	48	43	0.92	−1.5	5	4,695	w.	24	n.	16	15	14	2	3.7	0.0	0.0
Cheyenne	6,088	84	101	24.14	29.97	+.05	68.8	+2.1	94	4	82	46	14	56	37	54	45	51	0.92	−1.2	8	6,233	s.	35	sw.	19	8	14	9	5.6	0.0	0.0
Lander	5,372	60	68	24.73	29.94	+.02	70.4	+3.0	97	6	86	48	1	55	41	55	45	49	1.87	+1.2	8	3,112	sw.	29	s.	11	16	14	1	3.7	0.0	0.0
Sheridian	3,790	10	47	26.14	29.96	----	71.8	----	102	6	90	44	13	54	48	58	50	55	1.20	0.0	5	2,508	nw.	28	nw.	22	18	10	3	3.5	0.0	0.0
Yellowstone Park	6,241	11	48	----	30.02	+.10	63.6	+2.1	88	8	78	40	20	49	39	----	----	57	0.86	−0.4	12	4,999	sw.	36	sw.	26	5	22	4	----	0.0	0.0
North Platte	2,821	11	51	27.09	29.94	+.01	78.1	+5.2	102	7	92	55	1	64	38	64	57	56	0.60	−2.1	6	3,878	s.	30	ne.	5	21	4	6	3.4	0.0	0.0
Middle Slope							**79.8**	**+2.6**										**51**	**1.76**	**−1.2**										**3.6**		
Denver	5,292	106	113	24.84	29.98	+.07	74.0	+1.8	96	7	85	54	13	63	33	57	46	48	1.76	+0.1	8	4,562	s.	27	se.	4	9	15	7	5.0	0.0	0.0
Pueblo	4,685	80	86	25.35	29.92	+.01	75.0	+0.8	99	17	89	56	22	61	39	58	49	52	2.64	+0.7	6	4,165	e.	34	w.	27	7	19	5	5.1	0.0	0.0
Concordia	1,392	50	58	28.53	29.96	+.01	82.0	+4.0	106	27	94	57	14	70	34	67	58	51	2.17	−1.6	7	5,140	s.	22	ne.	28	20	6	5	3.1	0.0	0.0
Dodge City	2,509	11	51	27.44	29.97	+.04	81.2	+2.8	104	12	94	60	15	68	34	64	55	49	1.54	−1.6	6	6,090	s.	28	ne.	3	22	6	3	2.5	0.0	0.0
Wichita	1,358	139	158	28.56	29.94	−.02	82.3	+2.9	104	28	94	60	15	71	33	67	59	50	1.06	−2.3	6	8,510	s.	29	sw.	3	20	8	3	3.2	0.0	0.0
Broken Arrow	765	11	56	29.19	30.00	----	81.8	----	104	28	93	57	15	71	29	----	----	----	2.57	−1.3	2	6,771	sw.	42	nw.	3	18	8	5	3.3	0.0	0.0
Oklahoma City	1,214	10	47	28.73	29.97	+.01	84.0	+3.4	104	28	96	60	15	72	31	69	62	54	0.60	−2.3	2	5,654	s.	20	ne.	31	20	8	3	3.0	0.0	0.0
Southern Slope							**82.3**	**+1.1**										**50**	**1.11**	**−1.3**										**3.0**		
Abilene	1,738	10	52	28.20	29.96	+.03	85.2	+2.4	104	13	97	63	16	73	34	67	57	46	0.47	−1.6	3	6,224	s.	20	s.	9	20	7	4	3.1	0.0	0.0
Amarillo	3,676	10	49	26.34	29.97	+.05	79.6	+2.8	99	17	92	61	1	67	36	63	53	48	2.42	−0.4	7	5,585	s.	20	se.	30	21	8	2	2.7	0.0	0.0
Del Rio	944	64	71	28.97	29.94	+.04	85.0	−1.3	101	17	95	71	31	75	28	71	62	57	0.94	−1.5	3	6,821	se.	27	e.	8	22	8	1	2.8	0.0	0.0
Roswell	3,566	75	85	26.41	29.93	+.05	79.4	+0.5	97	13	92	60	16	67	33	63	54	48	0.60	−1.7	6	4,932	s.	26	se.	13	18	12	1	3.2	0.0	0.0
Southern Plateau							**79.4**	**+0.5**										**51**	**1.31**	**+0.1**										**4.0**		
El Paso	3,778	152	175	26.19	29.87	+.03	82.0	+0.9	102	1	93	62	27	71	31	64	54	46	1.33	−0.7	10	5,035	e.	32	ne.	4	11	19	1	4.2	0.0	0.0
Santa Fe	7,013	38	53	23.40	29.92	+.04	68.4	−0.6	87	4	79	54	22	58	27	56	49	58	4.32	+1.9	19	3,468	se.	28	n.	13	3	23	5	5.5	0.0	0.0
Flagstaff	6,907	10	59	23.48	29.91	+.08	64.5	−0.5	89	6	78	42	3	51	42	53	----	68	6.06	----	18	4,280	nw.	29	nw.	18	2	13	16	----	0.0	0.0
Phoenix	1,108	10	107	28.67	29.78	.00	91.3	+1.5	113	1	104	72	8	79	35	70	58	38	0.68	−0.4	5	3,835	e.	35	e.	8	14	12	5	4.4	0.0	0.0
Yuma	141	9	54	29.64	29.77	+.01	91.4	+0.6	113	14	106	69	3	77	40	73	63	46	0.21	0.0	4	3,491	se.	30	se.	30	25	4	2	2.1	0.0	0.0
Independence	3,957	6	27	25.88	29.85	+.02	79.0	+0.9	102	14	95	56	25	63	38	55	----	----	T.	−0.1	0	----	nw.	----	----	----	24	5	2	----	0.0	0.0
Middle Plateau							**74.7**	**+2.3**										**35**	**0.49**	**0.0**										**3.1**		
Reno	4,532	74	81	25.50	29.89	+.02	72.4	+4.9	100	14	90	47	27	55	43	54	41	39	T.	−0.2	0	4,450	w.	24	w.	15	22	5	4	2.4	0.0	0.0
Tonopah	6,090	12	20	----	----	----	73.0	----	90	14	85	53	10	62	30	52	34	25	0.31	----	3	----	se.	----	----	----	----	----	----	----	0.0	0.0
Winnemucca	4,344	18	56	25.62	29.93	+.03	72.8	+2.2	100	14	91	46	29	54	49	51	34	31	0.04	−0.2	2	3,876	sw.	22	nw.	18	22	6	3	2.2	0.0	0.0
Modena	5,473	10	43	24.67	29.88	+.02	70.8	+0.2	94	5	87	47	12	54	44	52	37	39	0.58	−0.5	9	7,328	sw.	38	s.	26	13	14	4	4.2	0.0	0.0
Salt Lake City	4,360	163	203	25.63	29.89	−.01	79.2	+3.5	100	5	91	60	11	68	32	59	46	36	0.84	+0.3	5	5,090	s.	32	sw.	31	19	11	1	2.5	0.0	0.0
Grand Junction	4,602	60	68	25.42	29.93	+.04	78.2	+0.5	101	5	91	59	22	65	34	59	47	42	0.99	+0.4	9	4,635	se.	28	se.	26	14	12	5	4.1	0.0	0.0
Northern Plateau							**74.2**	**+3.2**										**36**	**0.17**	**−0.4**										**2.8**		
Baker	3,471	48	53	26.46	29.99	+.04	68.0	+2.4	95	29	84	41	2	52	40	52	39	39	0.05	−0.5	2	3,487	se.	18	nw.	1	21	8	2	3.0	0.0	0.0
Boise	2,739	78	86	27.12	29.91	−.02	76.0	+3.1	104	14	92	49	19	60	40	56	42	34	T.	−0.2	0	3,281	nw.	16	se.	14	20	6	5	3.0	0.0	0.0
Lewiston	757	40	48	29.15	29.95	.00	77.5	+3.5	106	29	94	51	27	62	48	----	----	----	0.07	−0.4	2	2,316	e.	20	nw.	16	22	7	2	2.5	0.0	0.0
Pocatello	4,477	60	68	25.50	29.90	−.02	74.2	+3.4	98	5	88	46	20	60	38	55	40	37	0.88	+0.1	7	5,023	se.	31	s.	9	12	17	2	3.7	0.0	0.0
Spokane	1,929	101	110	27.95	29.96	.00	72.9	+3.9	98	9	87	50	7	59	39	55	40	38	T.	−0.7	0	4,124	s.	20	sw.	19	22	7	2	2.4	0.0	0.0
Walla Walla	991	57	65	28.90	29.95	−.02	76.7	+2.7	107	13	90	51	27	63	38	57	42	34	0.02	−0.4	1	2,723	w.	12	w.	16	25	2	4	2.1	0.0	0.0
North Pacific Coast Region							**63.5**	**+0.2**										**64**	**0.06**	**−0.6**										**4.3**		
North Head	211	11	56	29.92	30.15	+.07	55.6	−1.6	66	30	59	48	12	52	10	53	52	87	0.04	−0.9	2	10,172	n.	33	n.	1	4	15	12	6.4	0.0	0.0
Port Angeles	29	8	53	----	30.14	----	57.1	----	81	12	65	43	9	49	35	----	----	----	0.02	−0.5	1	5,357	w.	23	nw.	25	11	15	5	----	0.0	0.0
Seattle	125	215	250	29.96	30.09	+.05	63.0	−0.1	89	12	72	48	2	54	31	55	50	64	T.	−0.6	0	4,314	ne.	18	ne.	25	11	12	8	5.0	0.0	0.0
Tacoma	194	172	201	29.90	30.10	+.04	63.2	+0.4	88	12	73	46	2	54	31	----	----	----	0.01	−0.6	1	4,786	n.	29	sw.	12	10	18	3	4.5	0.0	0.0
Tatoosh Island	86	9	53	30.03	30.13	+.08	54.0	−1.1	65	12	58	46	3	50	18	52	51	93	0.48	−1.1	10	5,888	sw.	39	e.	12	1	9	21	7.9	0.0	0.0
Yakima	1,076	58	67	28.84	29.97	----	75.4	+4.0	103	13	90	51	3	61	36	56	41	35	0.02	−0.3	1	4,608	nw.	21	nw.	15	24	3	4	2.1	0.0	0.0
Medford	1,329	29	58	28.58	29.97	----	71.5	----	99	22	89	47	19	54	44	56	45	47	T.	−0.4	0	----	nw.	24	w.	12	25	5	1	1.8	0.0	0.0
Portland, Oreg.	153	68	106	29.92	30.08	+.03	66.6	−0.1	92	11	78	50	25	56	34	58	51	62	T.	−0.6	0	4,030	nw.	16	nw.	20	12	14	5	4.6	0.0	0.0
Roseburg	510	75	99	29.51	30.05	+.02	67.0	−0.4	94	11	81	47	26	53	38	56	47	57	T.	−0.3	0	3,415	n.	17	n.	6	22	8	1	1.8	0.0	0.0
Middle Pacific Coast Region							**66.8**	**−0.2**										**64**	**T.**	**0.0**										**3.0**		
Eureka	62	73	89	30.02	30.09	+.04	55.0	−0.5	63	29	59	47	20	51	13	52	50	84	T.	−0.1	0	4,133	nw.	21	n.	3	5	16	10	5.9	0.0	0.0
Red Bluff	330	5	58	29.51	29.85	−.04	81.5	+0.7	108	20	98	56	28	65	45	61	45	34	0.00	0.0	0	3,372	s.	16	n.	19	25	4	2	1.9	0.0	0.0
Sacramento	69	106	117	29.81	29.88	.00	73.2	0.0	106	14	90	50	28	56	46	61	53	59	0.00	0.0	0	5,887	s.	17	s.	15	29	2	0	0.5	0.0	0.0
San Francisco	155	208	243	29.79	29.96	+.01	58.6	+0.1	84	30	65	50	12	52	26	53	50	78	0.00	0.0	0	5,629	sw.	25	nw.	27	12	14	5	4.5	0.0	0.0
San Jose	141	12	110	29.82	29.97	----	65.8	−1.1	93	30	79	47	29	53	40	----	----	----	0.00	0.0	0	4,338	nw.	20	nw.	27	24	5	2	2.3	0.0	0.0
South Pacific Coast Region							**74.7**	**+1.5**										**58**	**T.**	**0.0**										**2.8**		
Fresno	327	89	98	29.52	29.86	+.03	81.6	−0.5	108	14	98	57	28	65	38	60	43	31	T.	0.0	0	5,283	nw.	19	nw.	29	24	4	3	1.6	0.0	0.0
Los Angeles	338	159	191	29.55	29.91	+.01	72.8	+2.6	98	14	83	58	25	62	27	62	57	65	0.00	0.0	0	2,915	sw.	13	w.	31	21	8	2	2.7	0.0	0.0
San Diego	87	62	70	29.81	29.90	−.02	69.6	+2.4	100	30	76	59	1	64	34	64	61	78	T.	0.0	0	3,925	w.	17	s.	30	15	13	3	4.1	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.94	30.03	----	80.4	+0.3	90	21	85	72	25	76	16	----	----	----	2.52	−3.4	18	10,241	e.	36	s.	25	7	22	2	4.9	0.0	0.0
Panama Canal																																
Balboa Heights	118	6	97	[1] 29.70	[1] 29.79	−.03	80.0	−0.3	93	16	88	72	26	75	18	----	----	[2] 84	4.04	−3.2	11	5,033	nw.	32	s.	7	0	10	21	7.6	0.0	0.0
Cristobal	36	6	97	[1] 29.78	[1] 29.81	−.04	81.6	+1.2	89	31	87	74	12	78	13	77	76	[2] 83	8.99	−6.7	22	7,066	n.	26	nw.	12	1	10	20	8.0	0.0	0.0
Alaska																																
Fairbanks	455	11	44	----	----	----	59.6	----	79	26	71	38	17	49	34	----	----	----	2.62	----	12	2,396	w.	----	----	----	4	16	11	6.4	0.0	0.0
Juneau	80	11	50	[1] 29.99	[1] 30.08	----	54.8	----	77	12	60	46	23	49	29	52	50	87	6.29	----	20	3,183	s.	22	nw.	23	6	1	24	8.1	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[1] 29.95	[1] 29.9	----	78.2	+0.5	85	6	83	70	14	74	15	70	67	70	0.22	−1.0	7	6,175	e.	24	e.	28	17	13	1	3.5	0.0	0.0

[1] Pressure not reduced to mean of 24 hours.

[2] Observations taken bihourly.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, June, 1930* *

LATE REPORTS, JUNE, 1930

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*In.*	*In.*	*In.*
Yarmouth, N. S.	65	29.86	29.93	−0.02	60.1	+5.1	68.1	52.1	80	42	0.69	−2.24	0.0
Kingston, Ont.	285	29.60	29.91	−.06	63.9	+0.5	71.1	56.7	80	48	2.89	+0.46	0.0
London, Ont.	808				66.7		77.6	55.7	88	43	6.54		0.0
Southampton, Ont.	656	29.18	29.89	−.08	62.3	+1.9	72.2	52.5	86	40	5.41	+3.06	0.0
Port Arthur, Ont.	644	29.14	29.85	−.09	61.4	+5.0	71.6	51.1	86	40	3.78	+1.05	0.0
Winnipeg, Man.	760	28.99	29.81	−.08	64.0	+1.8	74.8	53.3	87	37	2.55	−0.74	0.0
Minnedosa, Man.	1,690	28.02	29.80	−.09	61.5	+1.9	73.0	49.9	85	34	2.82	−0.18	0.0
Kamloops, B. C.	1,262	28.65	29.92	+.05	62.6	−1.2	73.1	52.1	90	44	0.71	−0.71	0.0
Estevan Point, B. C.	20				51.8		56.6	47.0	64	40	10.87		0.0
Prince Rupert, B. C.	170				52.2		58.9	45.5	75	40	6.02		0.0

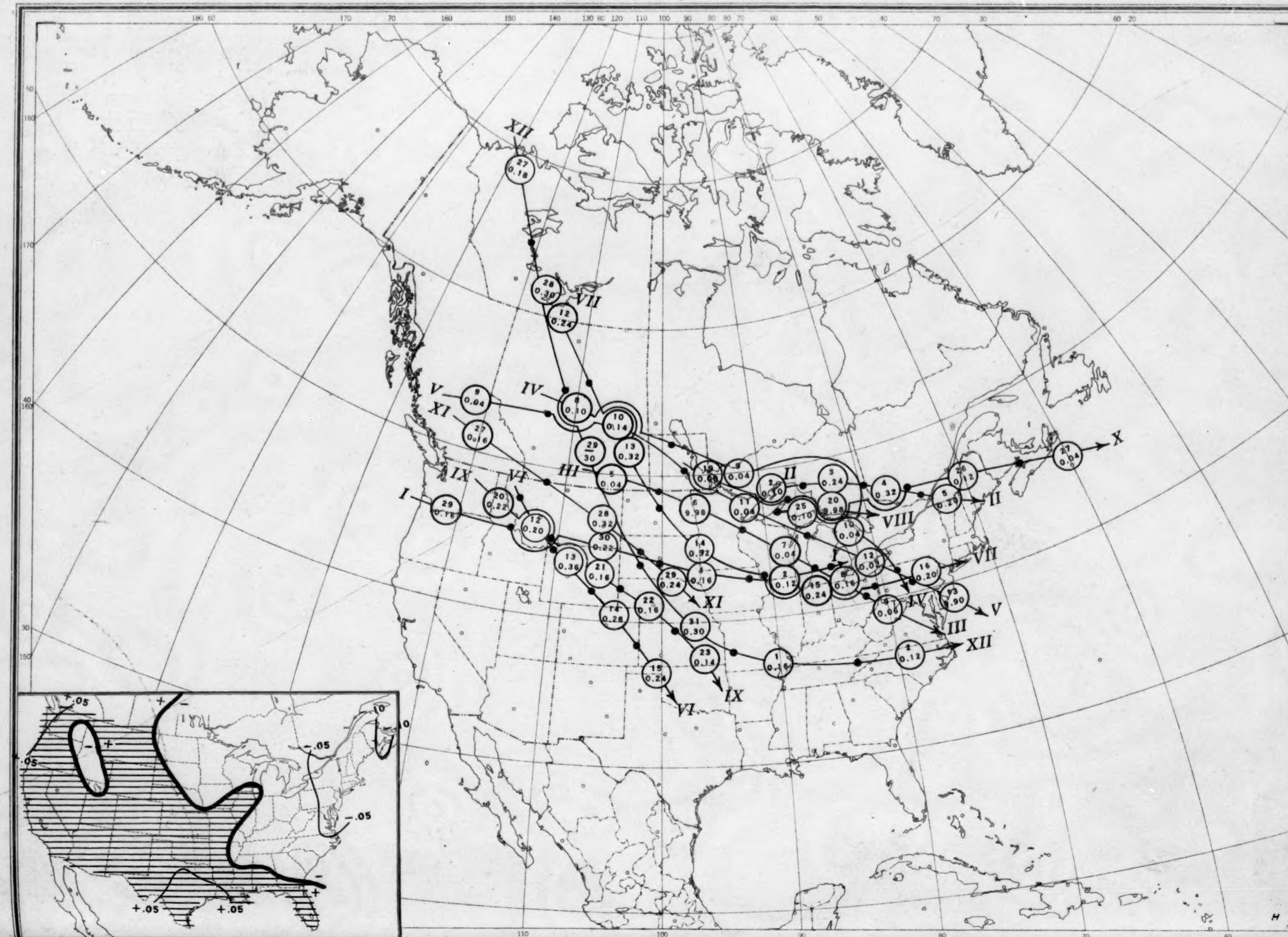
* Reports for July, 1930, delayed in transmission, to appear in August issue.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, July, 1930

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.

Chart II. Tracks of Centers of Anticyclones, July, 1930. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by Welby R. Stevens)



Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, July, 1930. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Welby R. Stevens)

Chart III. Tracks of Centers of Cyclones, July, 1930. (Inset) Change in Mean Pressure from Preceding Month

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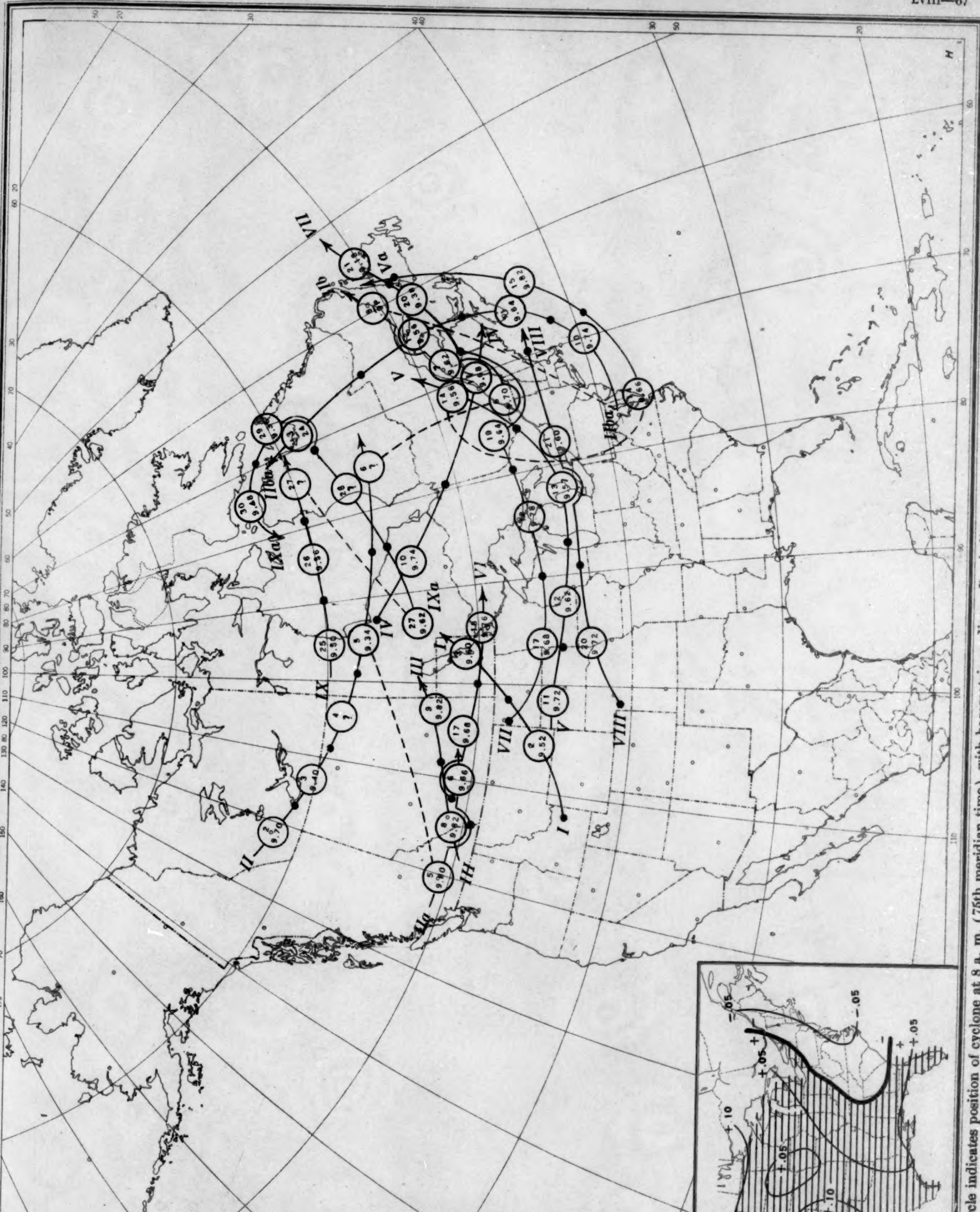


Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, July, 1930

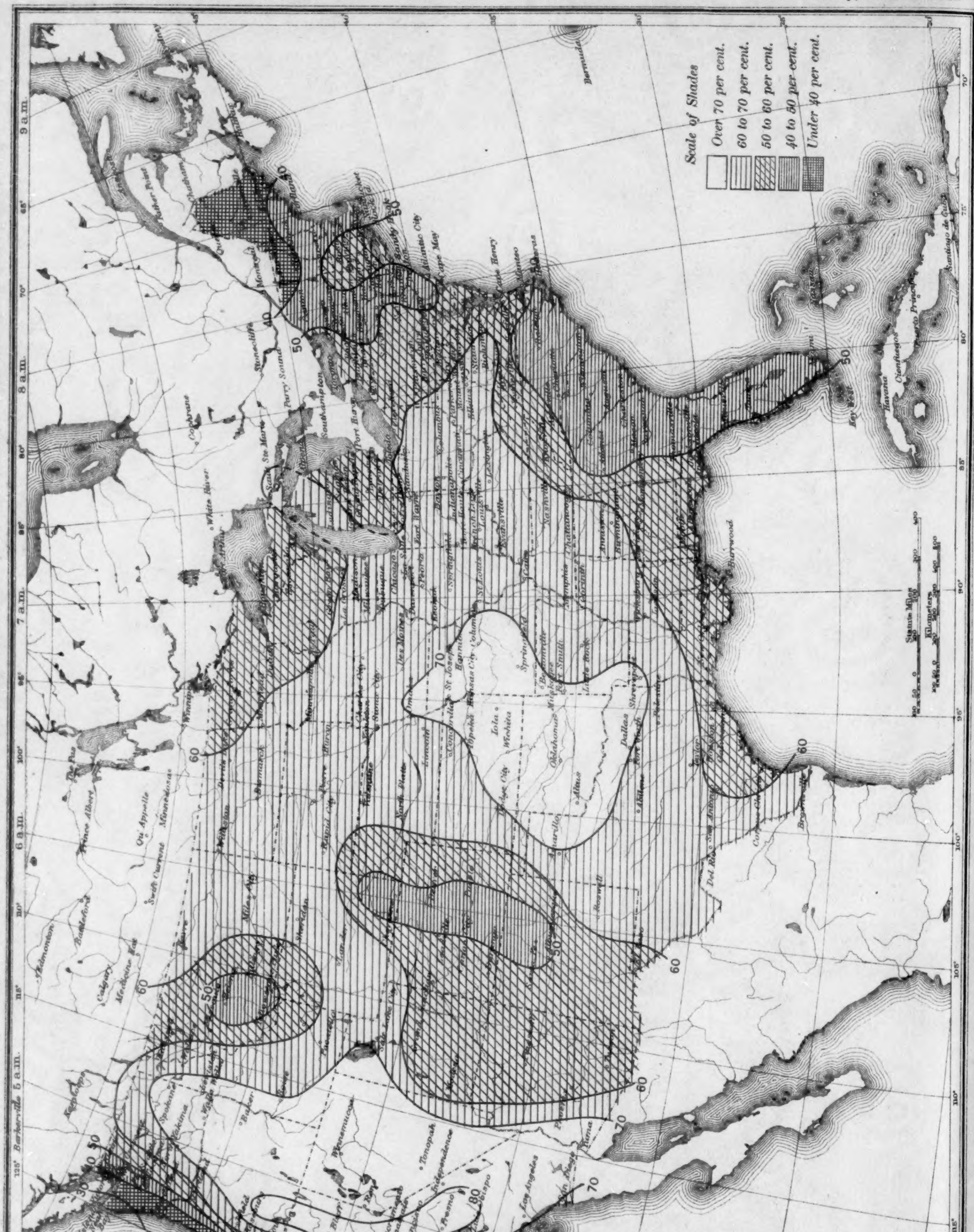
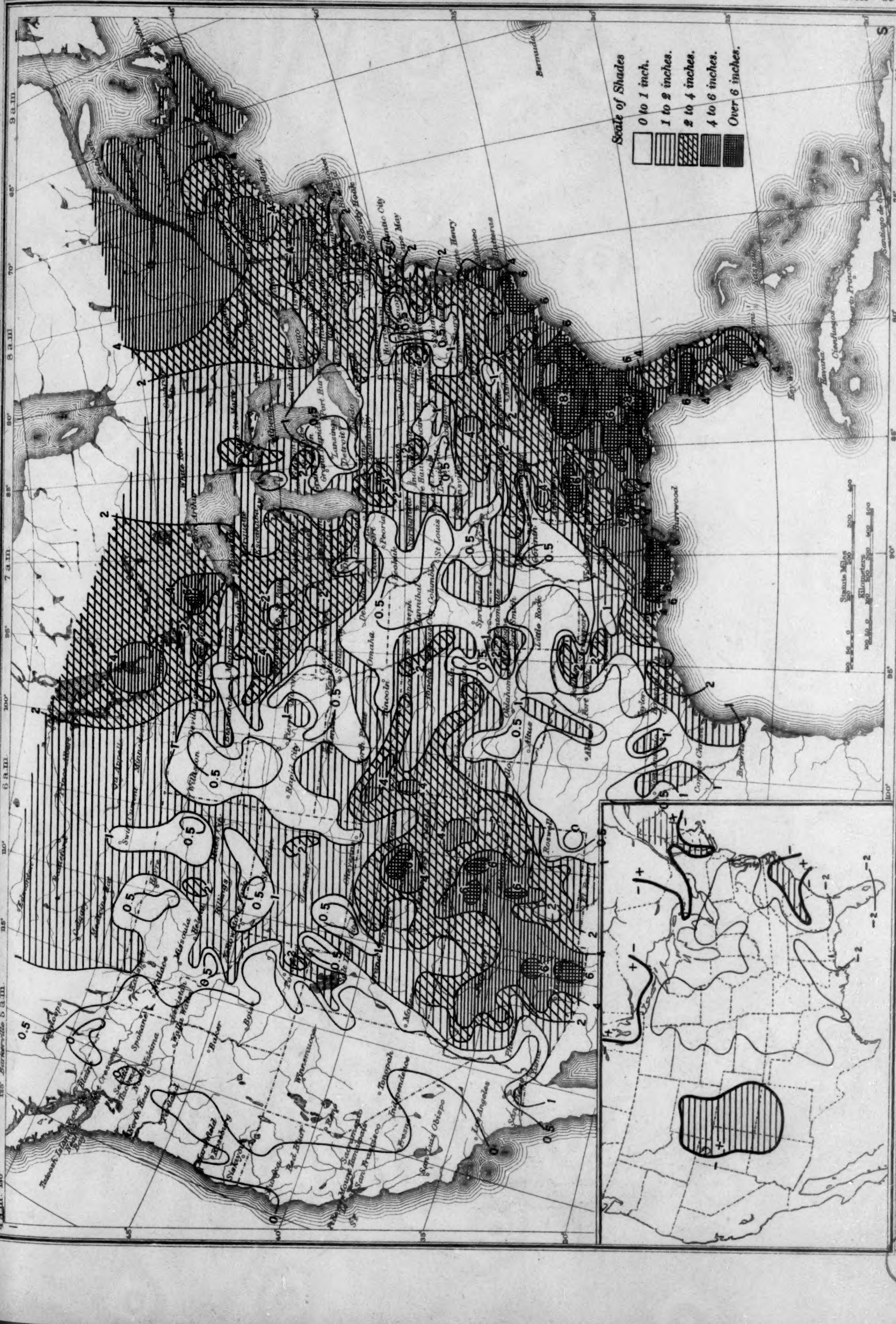


Chart V. Total Precipitation, Inches, July, 1930. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, July, 1930. (Inset) Departure of Precipitation from Normal



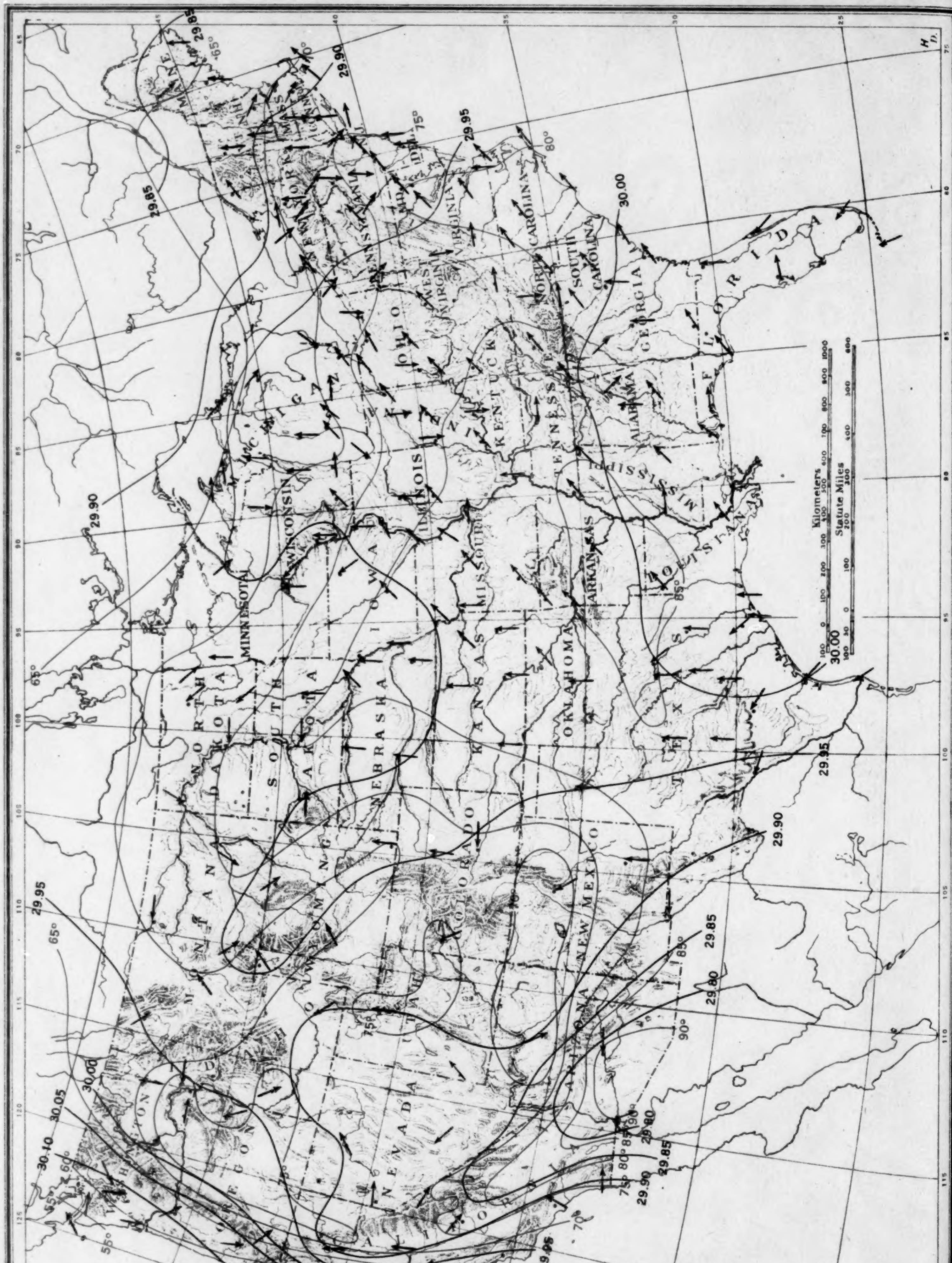


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, July, 1930